IBM Customer Engineering

Manual of Instruction

711 Card Reader, 716 Printer, 721 Card Punch

Issued to:_____

Department or Branch Office_____ Telephone Number_____

Address_____ City_____ State_____

Home Address_____ City_____ State_____

If this manual is mislaid, please notify the above address.

© 1959 by International Business Machines Corporation
Printed in U.S.A.
Form 223-6841

CONTENTS

IBM 711 CARD READER

1.0.00 INTRODUCTION E3

2.0.00 MECHANICAL DRIVE . . . E5

3.0.00 CARD FEED CLUTCH . . . E6
3.1.00 Card Feed E6
3.2.00 Card Feed Clutch E6
3.3.00 Card Feed Circuit Breaker Unit . E9

4.0.00 POWER SUPPLY E10

5.0.00 COMPONENTS AND CONTROLS . E11
5.1.00 Signal Fuse E11
5.2.00 Wiring Diagram E11
5.3.00 Control Contacts E11
5.4.00 Controls and Indicating Lights . E11
5.5.00 Control Panel E12
5.6.00 Dynamic Timer E13

6.0.00 CIRCUITS E16
6.1.00 Run-In of Cards E16
6.2.00 Information Transfer . . . E18
6.3.00 Card Disconnect and End of Record E18
6.4.00 Feed Interlock E19
6.5.00 Run-Out E19
6.6.00 Selectors E21

IBM 716 PRINTER

1.0.00 INTRODUCTION E25

2.0.00 FUNCTIONAL PRINCIPLES . . E26
2.1.00 Printing Capacity E26
2.2.00 Type Wheel Spacing . . . E26
2.3.00 Zero Print Control E27
2.4.00 Character Emitter E27
2.5.00 Selector Control E27
2.6.00 Alphabetic Printing . . . E27
2.7.00 Tape-Controlled Carriage . . E27

3.0.00 MECHANICAL PRINCIPLES . . E29
3.1.00 Location of Parts E29
3.2.00 Drive Mechanism E29
3.3.00 Magnetic Clutch E33
3.4.00 Print Mechanism E33
3.5.00 Variable Speed Drive . . . E33
3.6.00 Cone Clutch E33
3.7.00 Ribbon Feed E34
3.8.00 CR and CF Circuit Breaker Assembly E34

4.0.00 CIRCUIT DESCRIPTION . . . E35
4.1.00 Power Supply E35
4.2.00 Wiring Diagram E35
4.3.00 Controls, Indicating Lights and Switches E35
4.4.00 Printer Control Panel E36
4.5.00 Dynamic Timer E42

5.0.00 CIRCUITS E43
5.1.00 General E43
5.2.00 Start and Select Circuits . . . E43
5.3.00 Printing E44
5.4.00 Zero Print Control E47
5.5.00 Special Character Printing . . . E50
5.6.00 Transfer of Information and Disconnect E56
5.7.00 Selectors and Split Column Control . E58

6.0.00 IBM 922 CARRIAGE E60
6.1.00 Functional Principles E60
6.2.00 Major Circuits E60
6.3.00 Manual Controls and Circuits . . E61
6.4.00 Carriage Contol Relays E63
6.5.00 Normal Line Spacing and Selective Spacing before Printing . . . E63
6.6.00 Spacing after Printing and Space Suppression E65
6.7.00 Form-to-Form Ejection . . . E65
6.8.00 Controlled Skipping and Interlock Release E67
6.9.00 System Controlled Skipping and Spacing E67

IBM 721 CARD PUNCH

1.0.00 INTRODUCTION E69

2.0.00 MECHANICAL PRINCIPLES . . . E71
2.1.00 Machine Units E71
2.2.00 Drive Unit E71
2.3.00 Principles of Punching E71
2.4.00 Geneva Mechanism E73
2.5.00 Single-Revolution Timing Cam . . E74
2.6.00 Feed Knives E74
2.7.00 Punch Clutch E76
2.8.00 Oil Pump E76

3.0.00 CIRCUIT DESCRIPTION E78
3.1.00 Card Punch Power Supply . . . E78
3.2.00 Wiring Diagrams, Relay Charts, Cam Charts, and Timing Charts . E78
3.3.00 Controls and Indicating Lights . . E78
3.4.00 Card Punch Control Panel . . . E79
3.5.00 Dynamic Timer E81

4.0.00 CIRCUITS E82
4.1.00 Run-In of Cards E82
4.2.00 Initiating a Machine Cycle . . . E84
4.3.00 Transfer of Information and Disconnect E85
4.4.00 Feed Interlocks E86
4.5.00 Double Punch and Blank Column Dectection E87

FIGURE 1.0-1. IBM 711 CARD READER

IBM 711 CARD READER

1.0.00 INTRODUCTION

THE IBM 711 Card Reader Model 2 (Figures 1.0-1, 1.0-2, 1.0-3) is a card input source used with several computer systems. This manual does not deal with the card reader as a source to a particular computer, but shows its function as an input to any computer with which it might be employed.

The punched data may be in any of several formats and is read into the computer at the rate of 250 cards per minute. The reader itself has no ability to translate information. The translation of data must take place in the system employing the reader. Cards are fed into the reader 9 edge first, face down, and as such are read a row at a time: 9, 8, 7, and so on. The punches in a card provide outputs by column, each column having its own output. The system interprets and stores these outputs by means of a control panel provided at the reader. The external computer system may initiate the start and stop of reading and must provide synchronization for receiving and storing the data. The synchronization of the reader with the system is not considered in this manual.

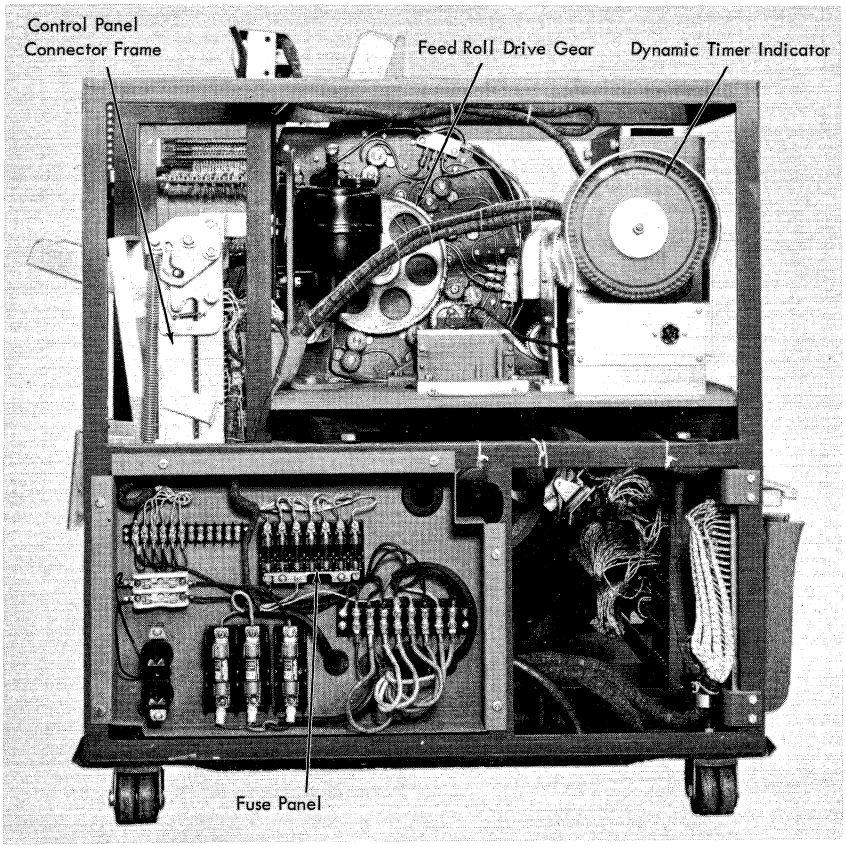


FIGURE 1.0-2. LEFT SIDE

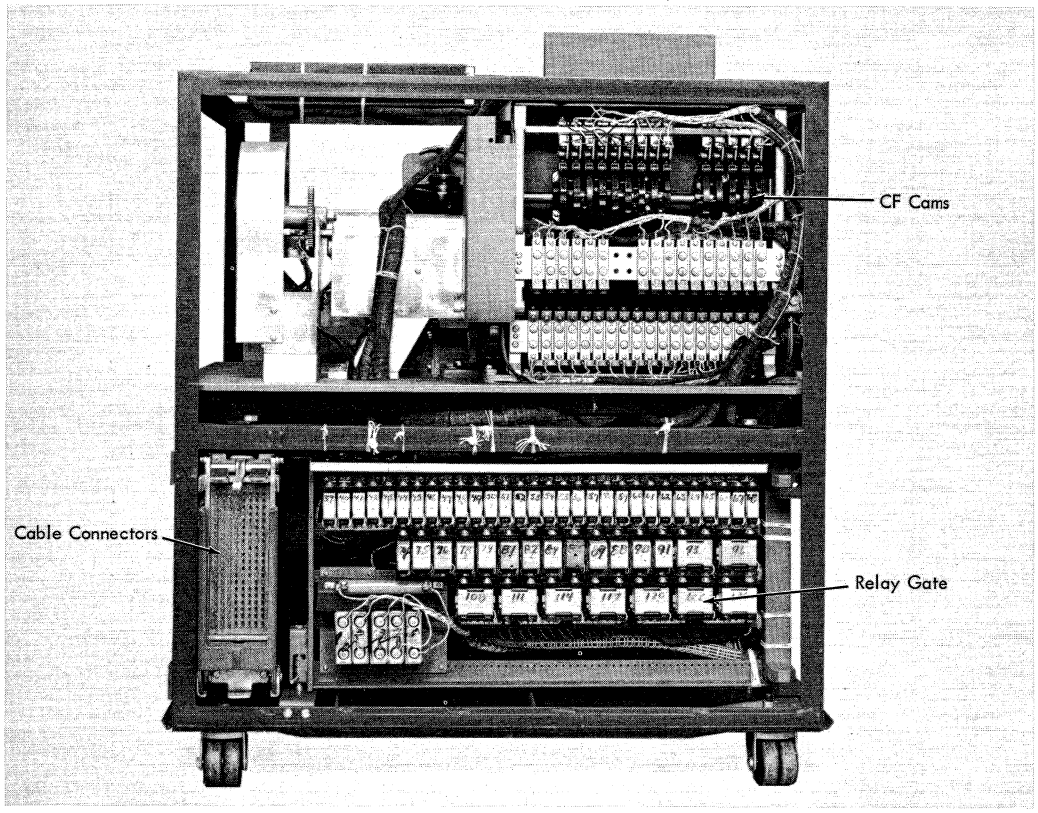


FIGURE 1.0-3A. REAR

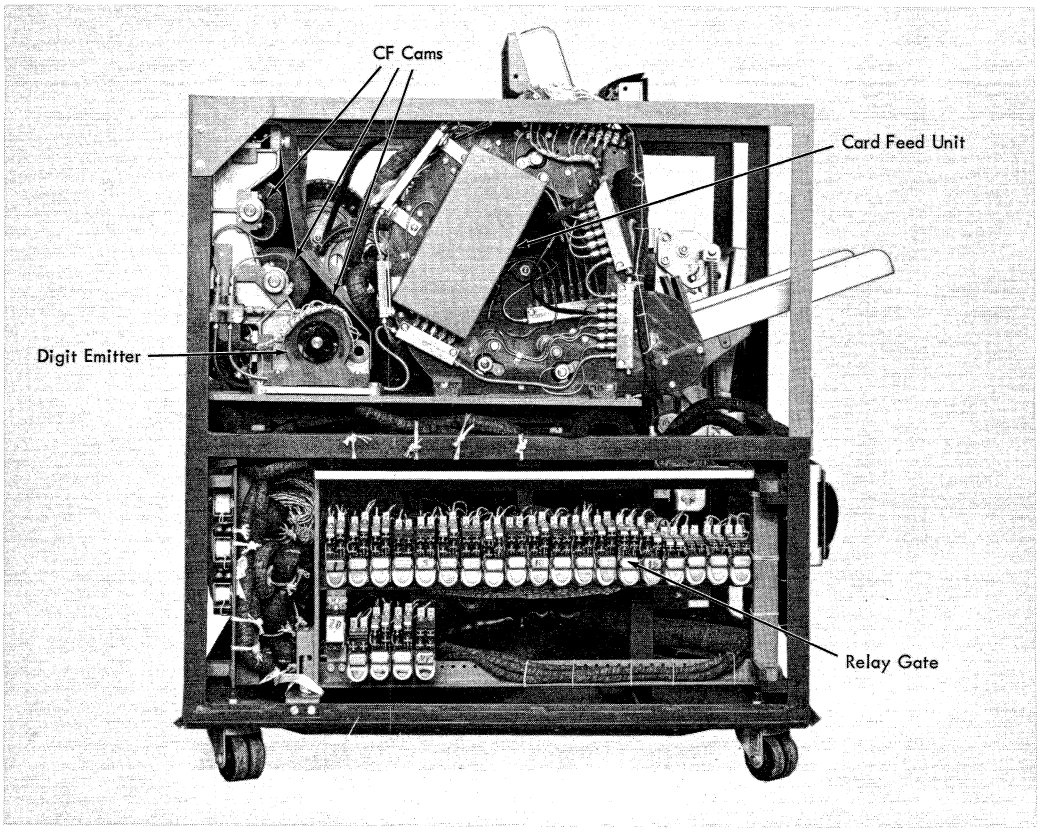


FIGURE 1.0-3B. RIGHT SIDE

2.0.00 MECHANICAL DRIVE

WITH THE MAIN line switch on, AC voltage powers a continuously running drive motor (Figure 2.0-1). A belt-driven gear reduction turns a continuously running shaft to which is attached a four-tooth card feed clutch disk. This disk transfers drive to the card feed unit through a ratchet type clutch.

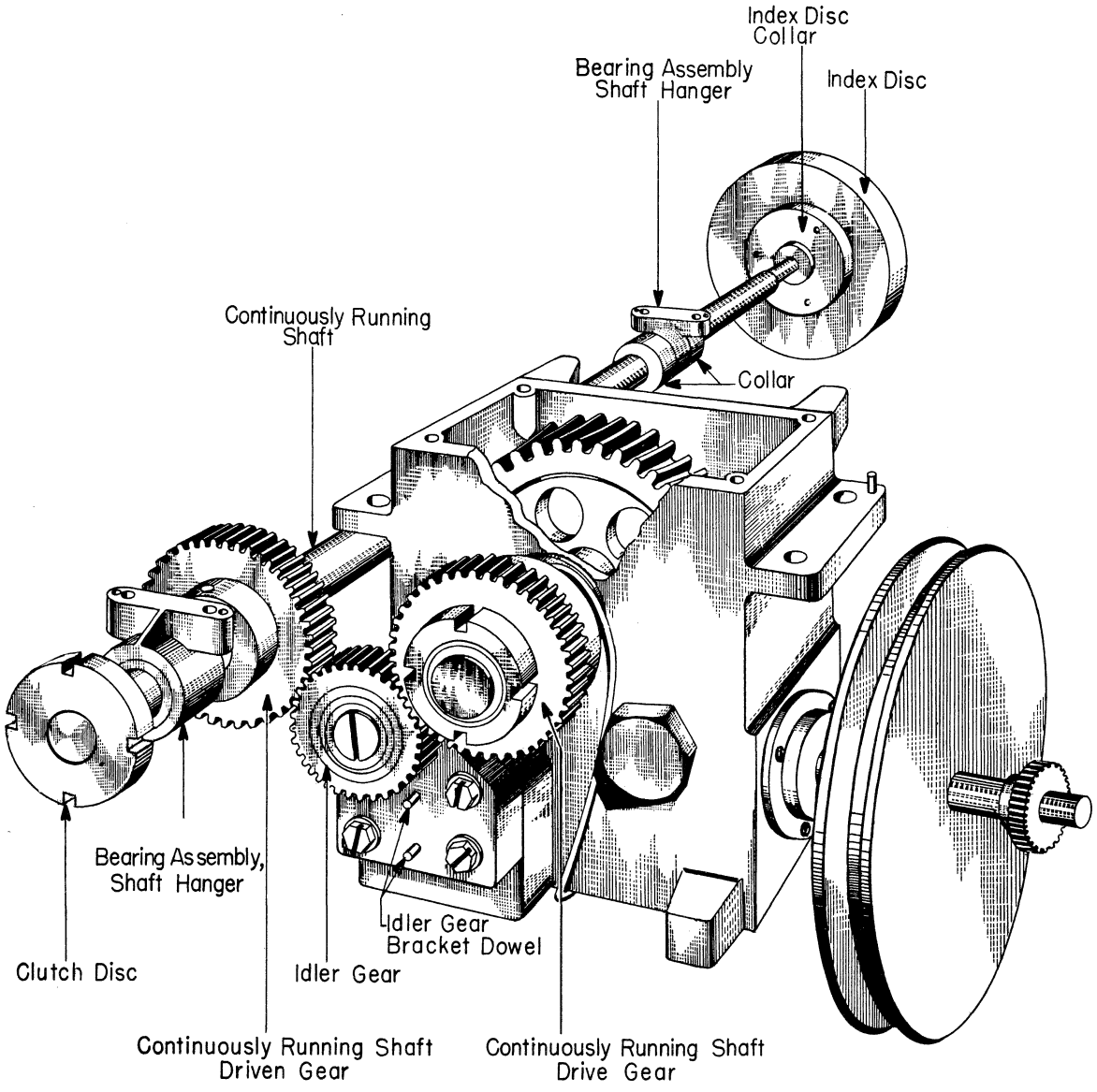


FIGURE 2.0-1. MECHANICAL DRIVE

3.0.00 CARD FEED UNIT

3.1.00 CARD FEED

The card feed, shown in Figure 3.1-1, employs mechanical feed knives to introduce the card into the unit. The card is engaged by two feeding knives that feed it through a throat. The throat is adjusted to permit passage of only one card per feed cycle. The feed knives are accurately timed and are designed to rock independently, so they may adapt themselves to the feeding of cards which may not lie perfectly flat on the hopper bed. The cards are placed in the feed 9 edge first, face down. At a fixed time in each card cycle, the feeding knives come in contact with the edge of a card and move it through the throat to the first set of feed rolls. A series of feed rolls under spring tension carry the card through the feed. The feed rolls are driven from the card feed clutch gear. As the card leaves the last set of feed rolls, it is gripped by the fingers of the stacker drum which carry it into stacking position.

The feed rolls carry the card past two brush stations. At each station there is a set of 80 brushes and a contact roll (Figure 3.1-2). The first set of 80 brushes, by means of control punches in the card, is used primarily to control the inputs to the calculator entry hubs. The second set of 80 brushes is used to read through the punched holes into the calculator entry hubs.

The card operates three contacts while it is in the feed unit: the hopper contact, the upper card lever contact, and the lower card lever contact (Figure 3.1-2). These contacts sense that a card is in the hopper, approaching the control brushes, or approaching the reading brushes.

3.2.00 CARD FEED CLUTCH

The card feed and the card feed cams are under control of the card feed clutch (Figure 3.2-1). The card feed clutch is controlled by the operator on run-in and run-out of cards, and by the system when cards are ahead of the reading brushes. The card feed clutch is a four-tooth ratchet type clutch which allows for starting the feed within one fourth of a revolution of the continuously running shaft.

When the clutch magnet becomes energized, the clutch pawl drops on the surface of the clutch disk. At 330° on the index, the tooth of the clutch disk comes under the pawl and the pawl engages with the tooth of the clutch disk. The clutch pawl arm is pinned to the card feed unit drive gear shaft; therefore, the feed knives, the feed rolls, contact rolls, stacker drum, and card feed cams are set in motion. If the card feed clutch magnets become de-energized during the feed cycle, the clutch magnet armature drops away from the stop screw. The tail of the clutch pawl strikes the armature latch at approximately 330° and is disengaged from the disk. If the armature remains against the stop screw, the clutch pawl is not disengaged from the clutch disk, and card feeding continues.

The card feed clutch armature is designed with a split latch. The split armature latch allows the card feed clutch pawl to remain engaged in the card feed clutch disk as late as possible as the index approaches 330°. Then, as the clutch pawl is disengaged from the clutch disk, the spring on the free portion of the latch lifts the pawl

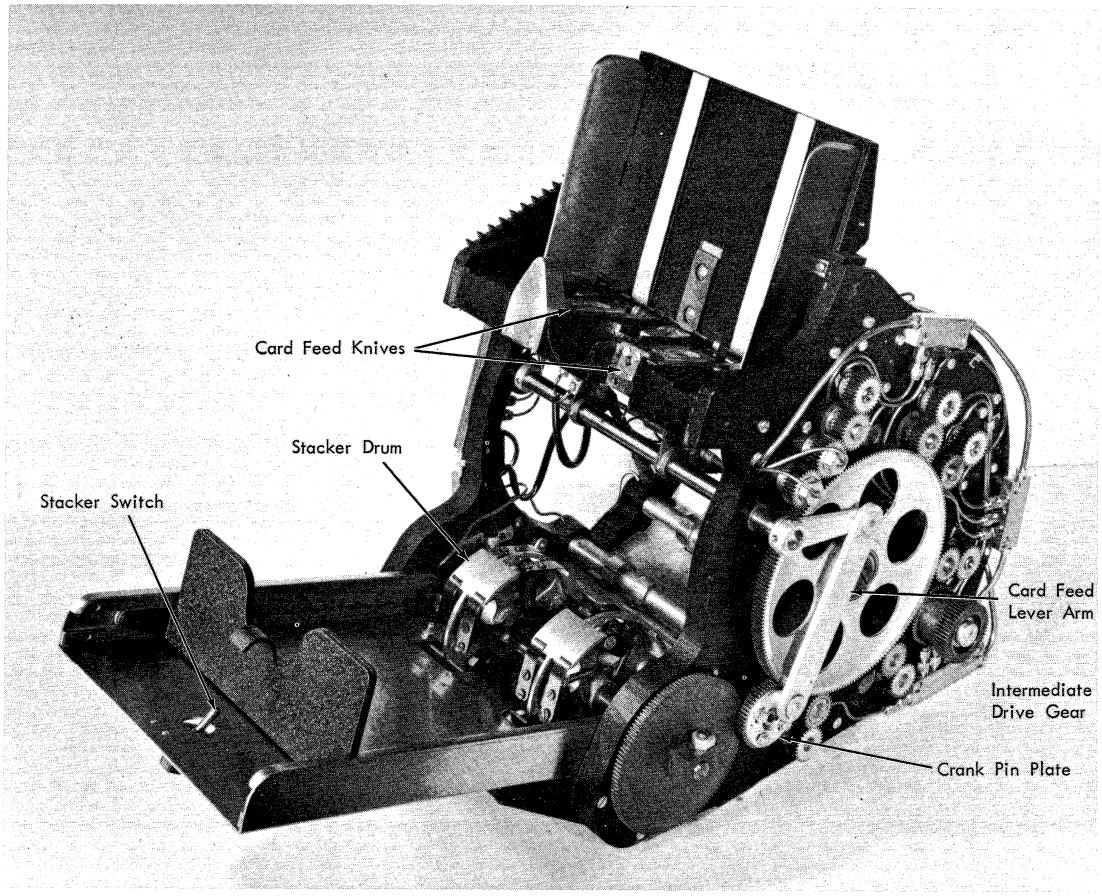


FIGURE 3.1-1. CARD FEED UNIT

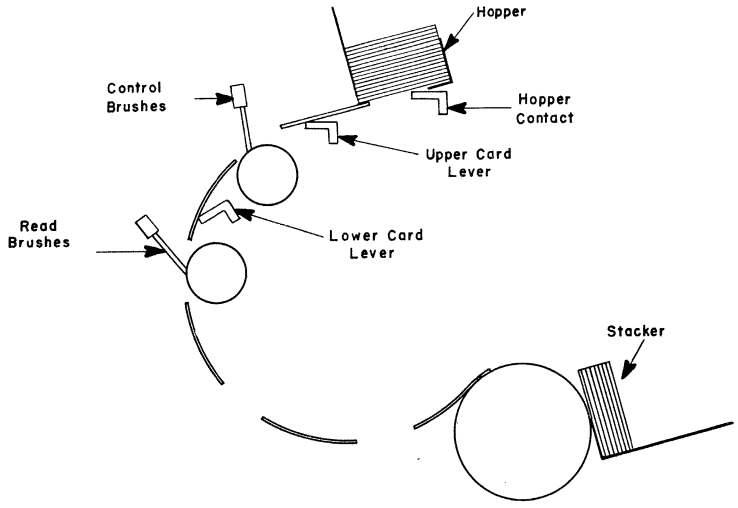


FIGURE 3.1-2. SCHEMATIC OF CARD FEED UNIT

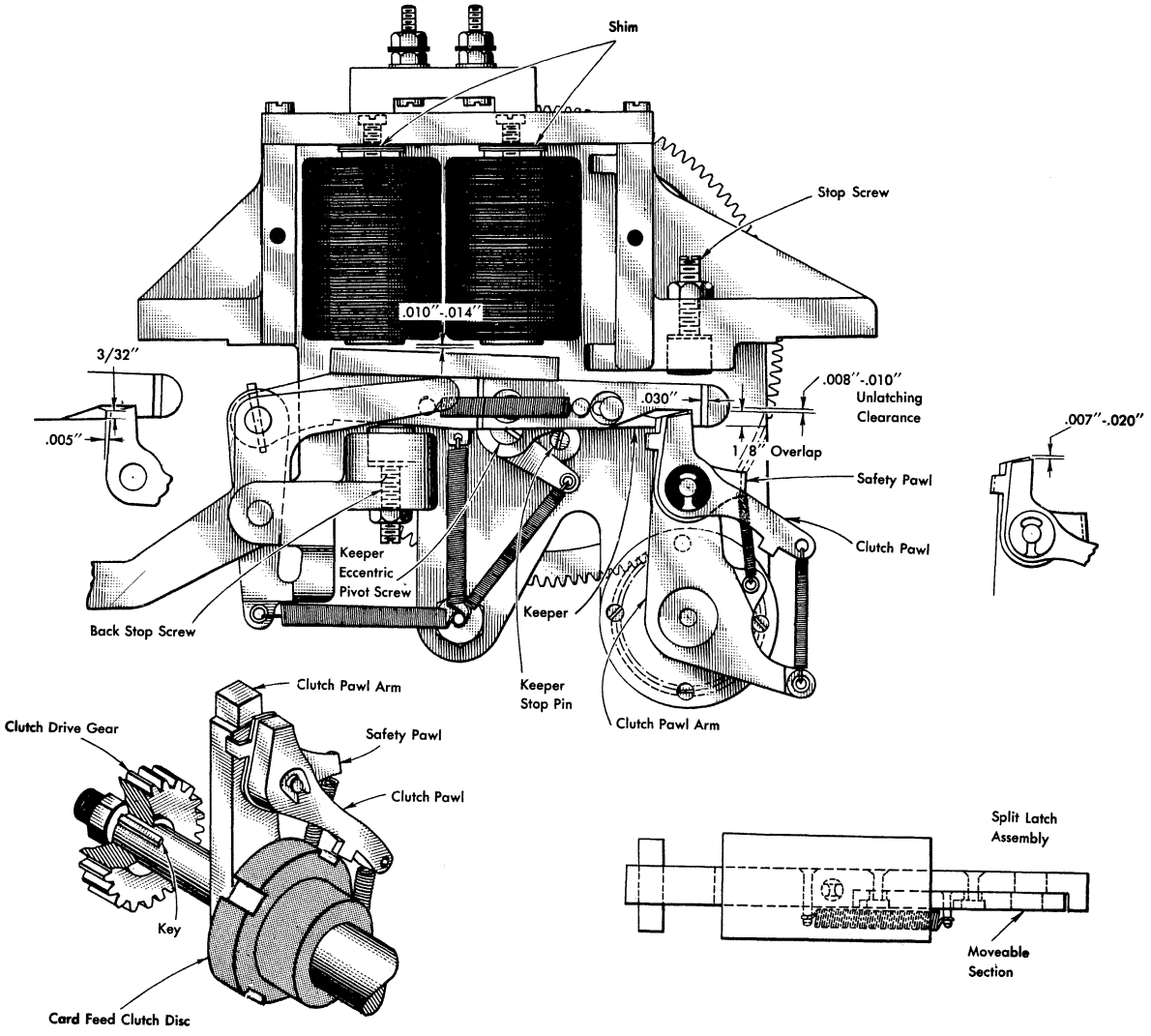


FIGURE 3.2-1. CARD FEED CLUTCH

sufficiently above the clutch disk to prevent nipping of the pawl or the disk when the continuously running shaft is in motion and the feed clutch magnets are not energized. The safety pawl, a small plate under spring tension mounted on the clutch pawl stud, swings forward into the path of the latch when the armature is attracted.

The purpose of the safety pawl is to prevent the armature latch from relatching the clutch pawl if the electrical circuits to the clutch magnets fail before the clutch pawl has engaged with the card feed clutch disk. Therefore, once the clutch pawl is released from the armature latch, the card feed unit must mechanically complete one machine cycle. The armature latch is attached to a yoke, which is held in position by the tension of the clutch lever yoke spring. The purpose of the spring is to absorb the shock when the clutch pawl arm latches up, and to return the arm to the 330^{o} position if it tends to move beyond this point.

3.3.00 CARD FEED CIRCUIT BREAKER UNIT

The card feed circuit breaker assembly is driven by the card feed clutch idler gear, and it operates with the card feed unit (Figure 3.3-1). Cams mounted on the three shafts in the circuit breaker unit revolve, and open and close the circuit breaker cam contacts for a mixed duration determined by the cut of the cam.

The first cam shaft in the card feed circuit breaker unit is equipped with a split block adjustment. This adjustment allows the entire unit to be brought into closer timing with the index than is possible by changing the drive gear relationship one full tooth.

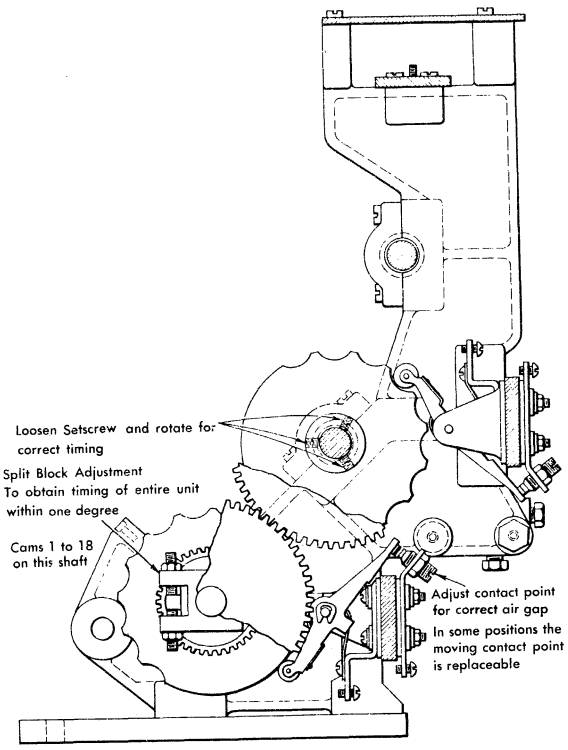

Loosen Setscrew and rotate for correct timing
Split Block Adjustment
To obtain timing of entire unit within one degree
Cams 1 to 18 on this shaft
Adjust contact point for correct air gap
In some positions the moving contact point is replaceable

FIGURE 3.3-1. CARD FEED CIRCUIT BREAKER UNIT

4.0.00 POWER SUPPLY

POWER FOR THE card reader drive motor comes from one side of 208v, 3-phase line. The motor operates whenever the power units are operating and the card reader main line switch is on.

The card reader requires two DC supplies. A 40v supply is required for the relay circuits and a 55v supply is required for the thyratron plate circuits. The printer generator supplies the 40v, and the printer rectifier supplies the 55v. These supplies are available when the printer HD relays are energized. The printer line switch and power supply interlock must be on.

5.0.00 COMPONENTS AND CONTROLS

5.1.00 SIGNAL FUSE

The card reader is equipped with a fuse panel using 5-amp signal fuses (Figure 1.0-2). Built into the non-transparent signal fuse cartridge is a small brass plunger held under tension of a compression spring by the 5-amp fuse wire. When a fuse wire breaks, the compression spring forces the plunger into contact with a bus bar mounted along each row of fuses.

Contact between any released plunger and a bus bar provides a pick-up for the signal fuse relay 21, whose point closes the circuit to the input-output fuse interlocks. It is important that the signal fuse (P/N 104909) be inserted in its clip with the plunger end toward the bus; the customer should always be instructed in the correct use of this type of fuse.

5.2.00 WIRING DIAGRAM

The wiring diagram for the card reader shows all contacts as they would be with the power turned off and the card feed clutch in its latched position. Systems Figures 29 through 32 of the wiring diagram show the card reader circuitry. In Systems Figures 33 and 34 the relay numbers and locations of the relay coils and points are listed. Systems Figure 35 shows the location of the relays on their gates. All information pertinent to the card feed cams and the card feed cam contacts is given in Systems Figures 36 and 37.

5.3.00 CONTROL CONTACTS

The feeding of cards is partly under the control of three card control contacts:

1. The lower card lever contact, which is closed when a card is in position to be read at the read brushes.
2. The upper card lever contact, which is closed when a card is in position to be read at the control brushes.
3. The hopper contact, which is closed when one or more cards are present in the hopper.

5.4.00 CONTROLS AND INDICATING LIGHTS

Start Key

The start key serves to run in cards initially and to turn control of the card reader over to the system. The key operates only if the power is on, no fuses are blown, there is no feed failure, the stacker is not full, the control panel is in place and jack-plugged on (reader on), and the stop key is not depressed.

If there is no card waiting ahead of the reading brushes, depressing the start key causes the card feed to operate one or more card cycles until either the key is released or until a card enters the station ahead of the lower reading brushes. When the first card reaches the station ahead of the lower reading brushes, the start key causes control to be turned over to the system and the ready light to turn on.

If there is already a card waiting ahead of the lower reading brushes, pressing the start key merely turns over control to the system and the ready light is turned on.

Stop Key

The stop key causes the system to lose control over the card reader and turns off the ready light. If a card is being read at the time the stop key is depressed, the action is delayed and the card reader does not stop until the end of the current card cycle. In this case, the stop key must be held down for a second to insure that it is effective.

Feed Key

The feed key permits cards to be run out of the card feed manually when the card reader is not under control of the system. If the power is on, no fuses are blown, the stacker is not full, and the ready light is off, depressing the feed key causes the card feed to operate for one or more card cycles until the key is released.

While the ready light is on, the feed key is inoperative. The stop key may be used to turn off the ready light in order to operate the feed key.

Ready Light

The ready light is on whenever the system interlock or end-of-cards interlock relay is energized. The light indicates that the card reader is under control of the system. While the ready light is on, no key can be used to feed cards.

Select Light

The select light goes on when the system selects this card reader. The light goes off as soon as the card cycle called for by the system has begun.

Card Feed Stop Light

The card feed stop light is on whenever the feed interlock is closed. It indicates that a card failed to feed from the hopper.

Power-on Light

The power-on light indicates that the DC power is on in the card reader.

5.5.00 CONTROL PANEL (Figure 5.5-1)

Control Brushes (Systems 8B). These hubs represent the 80 brushes that read the 80 columns of the card at the first station. They are generally used to control co-selectors and pilot selectors.

Read Brushes (Systems 8B). These hubs represent the 80 brushes that read the 80 columns of the card at the second station. They are generally wired to calculator entry hubs.

Calculator Entry Left and Calculator Entry Right (Systems 8B). These 72 hubs serve as inputs to the system. They are normally wired from the read brushes.

Co-Selectors (1-12) (Systems 4B). Each co-selector has five positions and may be used independently or in conjunction with the pilot selectors. When the selector is picked up, there is an internal connection between C (common) and T (transferred). When the selector is not picked up, there is a connection between C and N (normal).

Digit Impulse (D Imp) (Systems 8A). This hub is connected to CF37, which, in conjunction with CF33 and 34, allows the hub to emit an impulse for every digit 9 through 0 and X and R on each machine cycle when the card reader is under system control. The digit impulse hubs are inoperative the cycle point after a disconnect signal is received from the system. It is normally wired to the C of a digit selector to change the digit selector to a digit emitter.

Split Column Control (Systems 5A). These hubs emit impulses between reading pulse times. Hub 9 emits an impulse between 9 and 8 reading time. Hub 8 emits an impulse between 8 and 7 time. Hub 11 emits an impulse between 11 and 12 time. They are normally wired to immediate pickup of the pilot selectors or to co-selector pickups. The pilot selector or co-selector pulsed from a column split control hub transfers befor reading time for the succeeding cycle point.

Bus. These sets of common hubs are used to expand outlets or to bring outlets together to be directed to a single inlet.

Digit Selector (Systems 5B). These selectors are used to select specific digits in a card column or to emit digits on every system controlled feed cycle. The C hub is impulsed from the brushes if a digit from a specific column is desired, or from digit impulse if the selector is to be used as a digit emitter.

Pilot Selectors (System 4). The pilot selectors are two position selectors, each having an immediate 9-12 and 11-12 pickup. The 11-12 pickup receives an 11 or 12 impulse to transfer the selector on the following cycle. The 9-12 pickup receives any digit impulse to transfer the selector on the following cycle. The immediate pickup receives any impulse to transfer the selector immediately. The selector points remain transferred for the cycle during which the selector relay is energized. Each pilot selector has a coupling exit. The coupling exit hub emits an impulse the cycle following an 11-12 or 9-12 pickup of a pilot selector. The couple exit may be wired to a co-selector pickup to expand the pilot selector.

Card Cycles (Systems 5A). The card cycle hubs emit an impulse each feed cycle.

On (Systems 5B). The reader-on switch must be jackplugged on before the start key is operative.

5.6.00 DYNAMIC TIMER

A dynamic timer is provided to facilitate checking pulse timing and duration. A description of a dynamic timer unit is found in the printer section. The operation and circuits of the printer timer unit are the same as those of the portable unit used with the card reader and card punch.

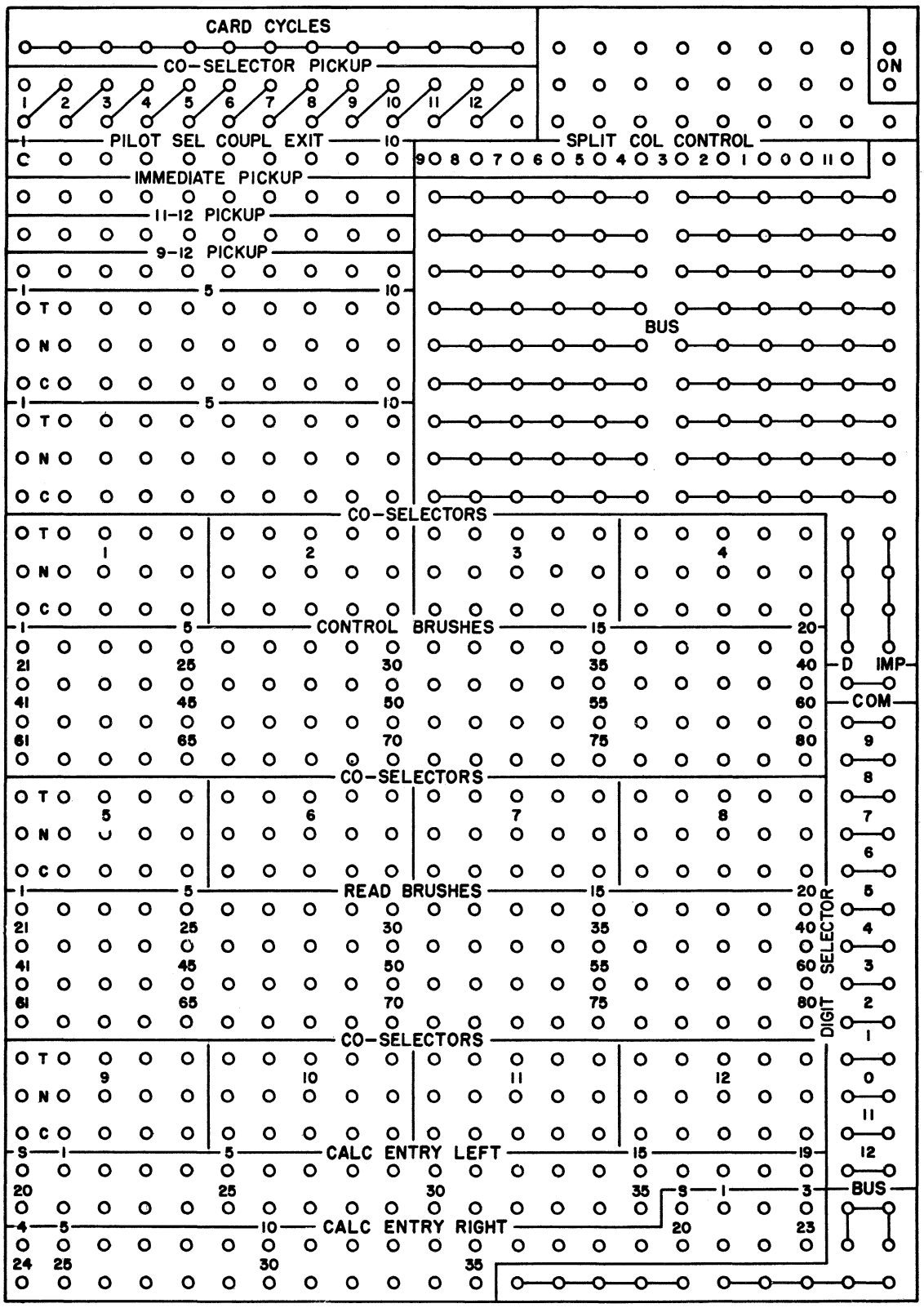


FIGURE 5.5-1. CARD READER CONTROL PANEL

6.0.00 CIRCUITS

CONSIDER THE condition of the card reader circuits when the power units are operating and the printer line switch is on (Systems Figures 29, 30, 31, and 32).

Relay 16 (Systems 6B) is up when the 55v bus is energized. Relay 17 (Systems 6B) is up whenever relay 16 and the 40v bus are energized, provided a fuse is not blown. Relay 17An/o points must be closed before the start or feed keys (Systems 1B) are operative. The power-on light comes on at the same time that relay 17 is energized.

Relay 9 (Systems 2A) is also energized. Relay 9 drops out whenever there are cards in the hopper or ahead of the brush stations. The points of R9 are used in the feed interlock and end-of-cards interlock circuits.

When the operator inserts the control panel with the reader-on switch (Systems 6B) jackplugged, R18 becomes energized. Relay 18An/o points (Systems 1A) must close to permit operation of the start key.

6.1.00 RUN-IN OF CARDS

To start the drive motor, the operator turns on the main line switch. See Figure 6.1-1. This causes the clutch disk to revolve at 250 RPM. When cards are placed in the hopper, R11 (Systems 6A) is energized and R9 is dropped out.

At this time the conditions are as follows: R11, 16, 17, and 18 are energized, and the clutch disk is turning. The card feed unit is latched at 330°. The first momentary depression of the start key causes the first card to be fed to a position just ahead of the control brushes. The auto-start relay, R1, picks from L_2, through the stop key, stacker stop switch, R17An/o, R18An/o, start key, R10ALn/c, R9BUn/c, R13BLn/c, CRCB1, and R1P to F2. R1 holds through R1AU CF32. A circuit to the card feed clutch magnet (Systems 2B) is then completed from L_1 through CF1 and R1BUn/o. This causes the clutch armature and latch to be attracted to the magnet core.

At 330° on the index, the clutch pawl engages the one-tooth ratchet of the clutch disk. This sets the card feed unit in motion. Once the clutch pawl is engaged in the ratchet, the motion of the card feed unit is mechanically controlled. The card feed unit must, therefore, complete the machine cycle. At approximately 155° of the first card feed cycle, the feed knives pick the bottom card and push the 9 edge through the roller throat. The first set of feed rolls grasps the card and carries it to a position just ahead of the first reading station (Figure 3.1-2).

The card mechanically closes the upper card lever contact before 220° on the index. At 220°, R12 (Systems 6A) is picked through the upper card lever contact and CF27. R12 is held through CF26 and R12AU until 225° of the next feed cycle.

The hold for the card feed clutch magnet is maintained through CF2 and a 100-ohm resistor until 285° of this first cycle. The purpose of the 100-ohm resistor in series with the clutch magnets is to provide pre-energization for the magnet coils. Without pre-energization, the clutch magnet would require 36° for full energization, making it necessary to allow 70° for the pickup of the clutch magnet with accuracy. With pre-

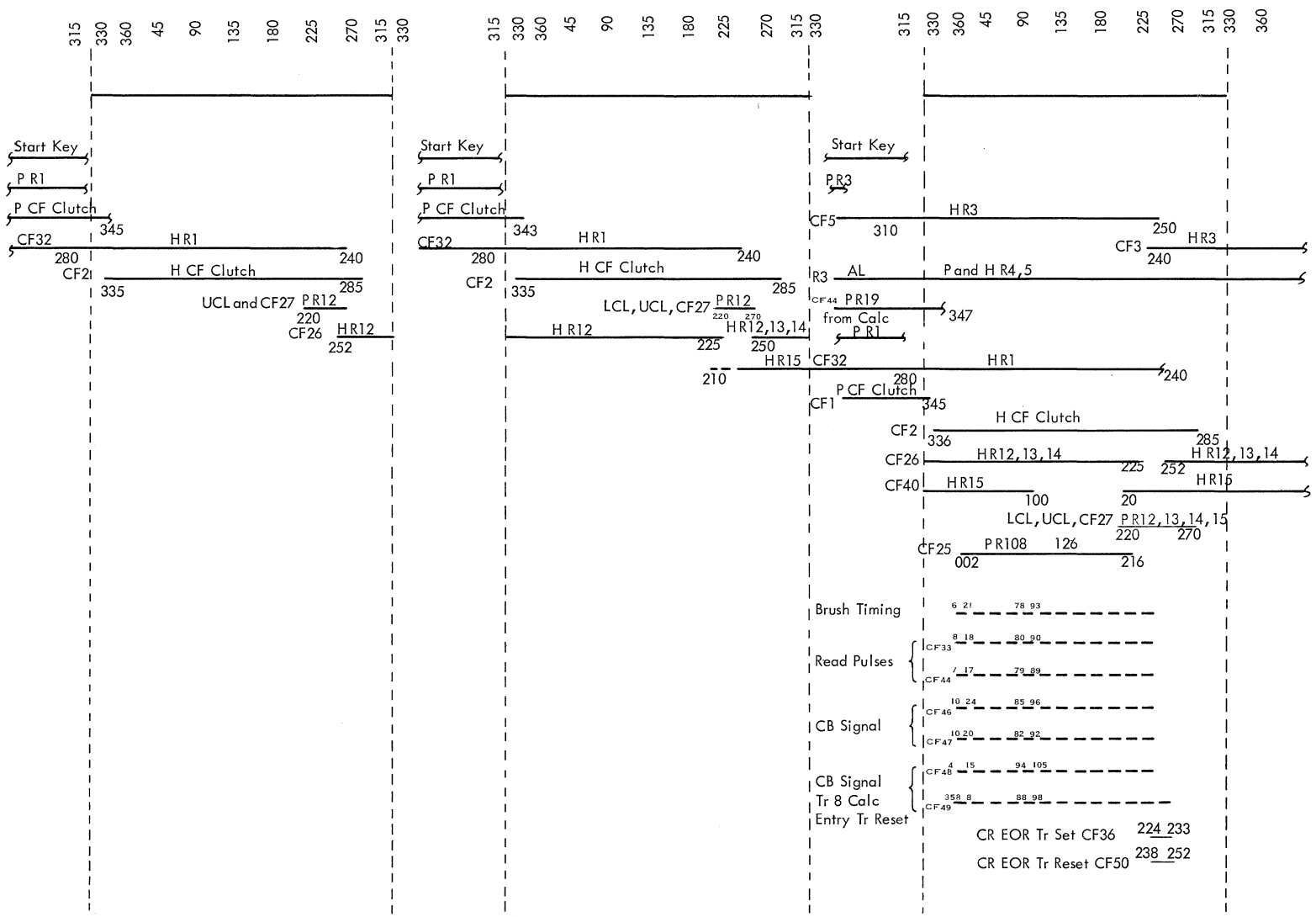


FIGURE 6.1-1. RUN-IN OF CARDS

energization the clutch magnets become energized in 18° with accuracy. This makes it possible to energize the clutch magnets much later in a cycle when successive feeding is required. The pre-energization circuit also serves as a hold circuit, once the magnet coils are energized.

R1BU opens at 240°; therefore, when CF2 breaks at 285°, the card feed clutch magnet is de-energized. At 330° the card feed clutch pawl is mechanically disengaged from the ratchet of the clutch disk. The feed unit stops with R12 energized, in addition to R11, 16, 17, and 18.

The second momentary depression of the start key causes the first card to be fed to a position just ahead of the reading brushes, and the second card is fed to a position just ahead of the control brushes.

The auto-start relay and the card feed clutch magnets are energized and held as described previously.

As the first card is fed under the control brushes, the read impulses are made available at the control brush exit hubs (Systems 8B). The circuit is from L_1, through CF33, 34, and 35, R12BUn/o, and the holes in the card, to the control brush hubs. Impulses from these hubs are generally used to pick selector relays.

Before 220° of this second cycle, the upper and lower card lever contacts close (Systems 6A). R12 remains energized because this second pick overlaps the hold cam time. R13, 14, and 15 become energized at 220°, through CF27 and the lower card lever contact. R12, 13, and 14 hold through CF26 until 225° of the next feed cycle. R15 holds through CF40 and 15AUn/o until 100° of the next feed cycle.

The card feed clutch magnet is de-energized at 296°, and the card feed unit latches at 330° with R11, 12, 13, 14, 15, 16, 17, and 18 energized.

A third depression of the start key turns the ready light on, and turns the card feed clutch control over to the system. Further depressions of the start key, while there are cards in the hopper and ahead of the brush stations, have no effect on the card reader operation.

The third depression of the start key causes R3 hold coil (Systems 2A) to be energized. The circuit is from L_2, through the stop key, stacker stop, R17An/o, R18An/o, start key, R10ALn/c, R14AUn/o, R5BLn/c, and R3H to F2.

R3H is held through R3AUn/o and CF5. The R3 pick coil is held through R3BUn/o, R10BUn/c, R14BUn/o, CF3, and R11AUn/o or R8BUn/o, depending upon the location of the cards in the feed unit. R3 turns the card feeding control over to the system. Therefore, the R3 pick and hold circuits have been designed so that R3 is energized whenever the system should have control over card feeding. R3H coil is used for picking, since it may remain energized for long periods when the machine is not in use. R3P is used only as a running hold.

The R3ALn/o point closes the circuit to R4 and R5 (Systems 2A). R4 and R5 are up whenever R3 is energized.

The ready light (Systems 6B) is turned on through R4BUn/o.

The card reader can now feed cards under system control when R19 (Systems 6B) is energized.

The card reader read-select synchronization circuit is shown in Systems 5B. The circuit is from the 55v bus, through CF44, to the system as a control line. The system in turn sends back a control line to the R19 pick coil. With R4 and R19 up, the auto-start relay picks, and the card reader feeds another card.

The card reader may be selected at any time between 005^{o} and 347^{o}; it might be selected before the cards are run into the read brushes. In this case, R19 is held energized through 14BLn/c (Systems 5A) until a card is ready to be read at the reading brush station. CF44 opens at 347^{o} to drop R19. CF44 again returns control to the system at 5^{o}. This permits a second CR select instruction to be executed if disconnect should occur at 9 time of the card reader cycle.

6.2.00 INFORMATION TRANSFER

Impulses from the reading brush hubs (Systems 8B) to the calculator entry hubs are made available through CF33 and 34, R5BUn/o, R20-4n/c, CF37, the punched holes, the points of the brush isolation relays, and the control panel wires. The brush isolation relays (Systems 31A) are picked up during card reading time through R4AUn/o, R20-2n/c, and CF25. The brush isolation points are closed only while the card is separating the brushes from the contact roll.

Take reading time 5 as an example. The brushes drop into the 5 holes, from 77^{o} to 78^{o} 30'. At approximately 80^{o}, the column having 5 punches are sampled through the calculator entry hubs by the system.

6.3.00 CARD DISCONNECT AND END OF RECORD

The reading circuits of the card reader can be disconnected from the system during any one of the 12 read cycle points or during the EOR trigger set impulse.

When the card reader select is disconnected in the system, the disconnect relay, R20 (Systems 6B) must be picked. The purpose of the disconnect relay is to suppress all card reader outputs to the system for the remainder of the cycle. The card reader outputs, which are common with the punch and printer, must be suppressed to prevent interference if a new select of a card machine occurs while the reader is completing its cycle.

The disconnect relay, R20, is energized through CF44 and the disconnect control of the system. The R20 points open the circuits to the brush isolation relays, CB signal trigger set, the reading brushes and digit impulses.

The data disconnect occurs during CB signal trigger set. In order to restore the card control circuits in the system, one more CB signal trigger reset must occur. Relays R22 and R23 (Systems 8A) provide this function. This last CB signal trigger reset picks R22 through R20-1n/o. Note that this occurs between cycle points. R22 holds through R22AUn/o and CF38 for the remainder of the cycle. On the next cycle point, a circuit through R5AUn/o, CF46 and CF47, R20-3n/o and R22BUn/o picks R23. R23 holds through R23AUn/o and CF38 for the remainder of the card cycle. R23BUn/c opens the CB signal and EOR trigger resets.

6.4.00 FEED INTERLOCK

The card reader running circuits are interlocked to prevent the card feed from continuing to run after a card has failed to feed from the hopper (Figure 6.4.1).

When a card fails to feed from the hopper, the card feed latches and the card feed stop light comes on (Systems 2A).

R10 (Systems 2A), the feed interlock relay, picks after R12 drops at 225° of the feed cycle during which the misfed occurred. R10 picks through L_2, R13ALn/o, R12ALn/c, and R11ALn/o. R10 holds through R10AUn/o and R9AUn/c, or through R10AUn/o, R10BLn/o and the stop key. The R10BUn/o points open the R3 running hold circuit. At 250°, when CF5 opens, R3, 4, and 5 drop out.

The 9AU point prevents dropping R10 until the cards have been removed from the hopper and runout from the lower brush station.

The cards should first be removed from the hopper and the feed key should be depressed until the last cards have been run out of the feed. Depressing the stop key releases the interlock.

Information in the card that is ahead of the read brushes when the card feed stops is not transferred to the system because the calculator interlocks R3, 4, and 5 are down when the card feeds past the read brushes. The R5AUn/o and R5BUn/o points open the CB signal trigger set and reset circuits and the read brush circuits, respectively.

After replacing the defective card, the last card run out should be placed in front of the deck. The start key should then be depressed to run-in the cards again.

Had the card reader been selected during the misfeed cycle, the card reader select control would have been held by R2BUn/o (5A) on run-out and by R14BLn/c on run-in. The system programming, therefore, has not been disrupted.

6.5.00 RUN-OUT

When the last card feeds from the hopper, the card feed stops. The operator then depresses the start key once if no more cards are to be run, in order to turn over control of the feed to the system for reading the final two cards (Figure 6.5-1).

A single depression of the start key puts the card feed under system control for three feed cycles. The first two cycles are used to read the final two cards. The third cycle is an end-of-file cycle. The end-of-file impulse sent to the system during this third cycle tells the system that all the cards have been read.

As shown in Figure 6.5-1, R11 drops at 219° of the cycle during which the last card is fed from the hopper. The R11AUn/o point opens the R3 running hold circuit. When R3 drops at 250°, R3ALn/o opens the hold to R4 and R5. R3BLn/o opens the pick to R1. The CF clutch magnets cannot pick through R1BUn/o. The feed latches at 330°, with R12, 13, 14, 15, and 19 (if reader select has been given) held energized.

To give the system control again over the CF clutch, the start key must be depressed.

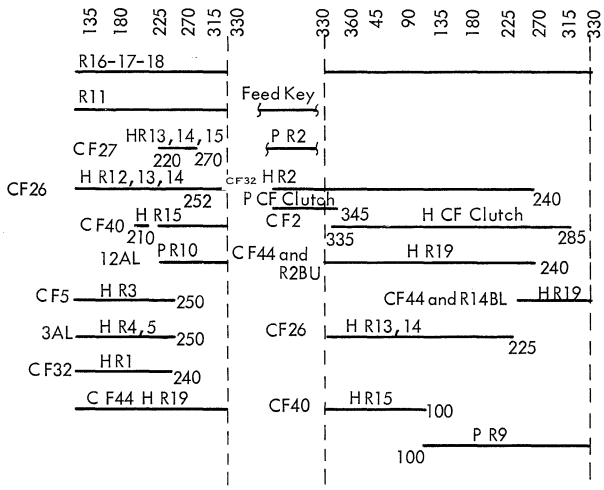


FIGURE 6.4.1 FEED FAILURE

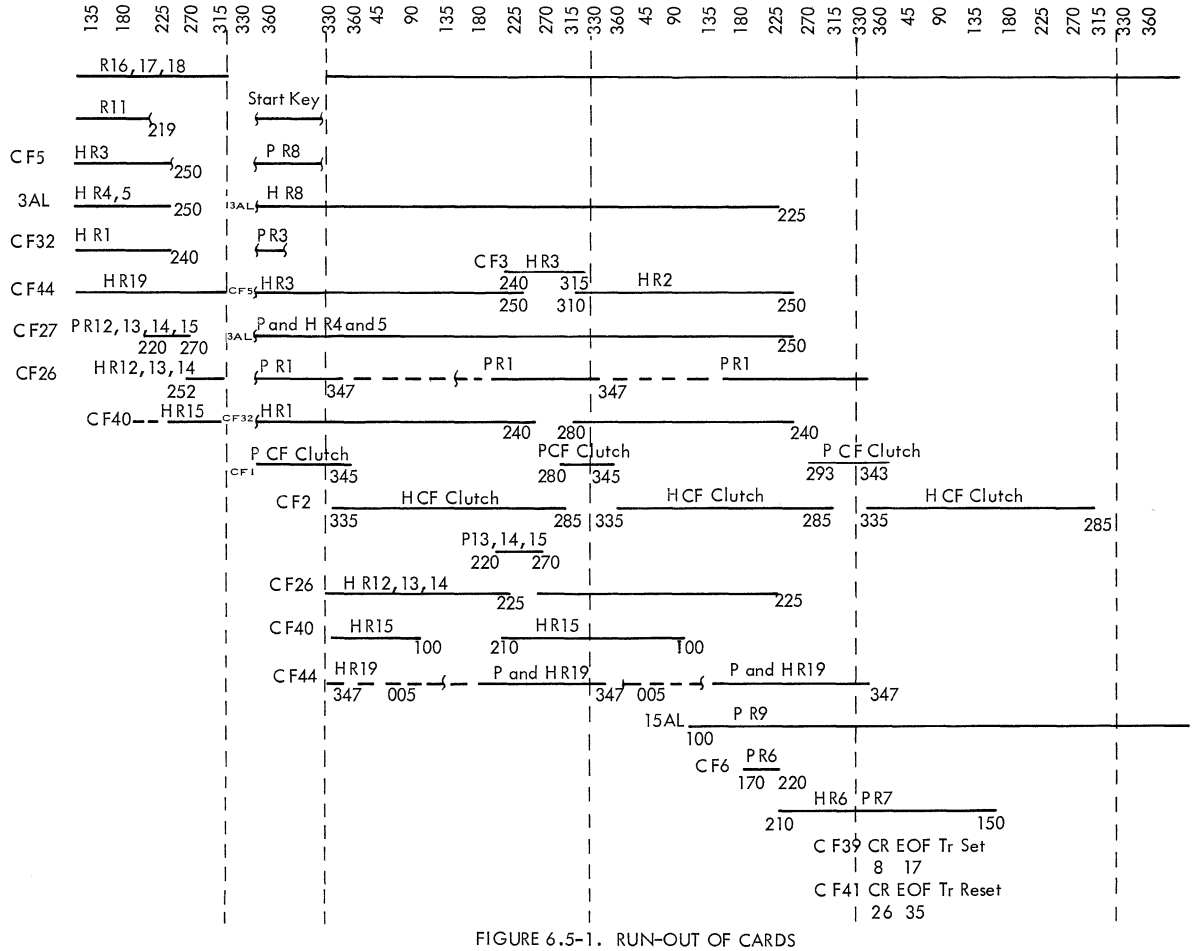


FIGURE 6.5-1. RUN-OUT OF CARDS

R3H coil is picked through the start key, R10ALn/c, R14AUn/o and R5BLn/c. R8 (Systems 2A), the end-of-file relay, picks through the start key, R10ALn/c, R14AUn/o, and R11BUn/c. R8BUn/o closes to maintain a running hold on the R3P coil. R3ALn/o picks R4 and R5. R1 picks through R3BLn/o, provided the system has called for a reader feed.

The CF clutch magnet is energized through R1BUn/o and the card reader feeds cards past the brushes. There is no card to close the UCL contact; therefore R12 drops out at 225°. This action opens the control brush circuit.

If the system does not select the card reader before 290°, the feed latches. The feed clutch is still under control of the system. When R19 is picked again, the last card feeds past the read brushes. The LCL contact is not closed; therefore, R13, 14, and 15 drop out. R9 picks after R15 drops at 100°. R8 drops when R13 is de-energized at 225°. Relays 3, 4, and 5 drop.

Before this time, from 170° to 220° , CF6 was made to pick R6 through CF5, R3AU n/o, R8AUn/o, CF6, and R9BUn/o. R6 holds and R7 picks through CF4 until 150° of the next feed cycle. R6BUn/o lights the ready light.

If the system selects the card reader before the CF clutch de-energizes, the reader takes an end-of-file cycle immediately. Otherwise, the card feed latches up with R6 and 7 energized.

When the read cycle is called for, the auto-start relay becomes energized through R6ALn/o and R19An/o. The CF clutch is energized through R1BUn/o and CF1, and the end-of-file cycle is initiated. At the beginning of 9 time, the end-of-file trigger set pulse (7B) is directed to the EOF control through CF33, 34, 35, R7BUn/o, and CF39. At 8 time the EOF reset pulse resets the EOF control through CF41 (Systems 7B).

6.6.00 SELECTORS (Systems 3B)

Selector T (transfer) and N (normal) hubs are connected to stationary points of a wire contact relay. The N and C (common) hubs are connected when the selector relay is not energized.

Co-Selectors

The co-selector T and C hubs become internally connected a few milliseconds after the co-selector relays are impulsed. A co-selector relay picked up at any time after 252° of a feed cycle holds until 225° of the following feed cycle. Any pulses directed into the C hubs appear at the T hubs. The co-selector relays hold through their 1n/o points and CF9. Each co-selector has five positions.

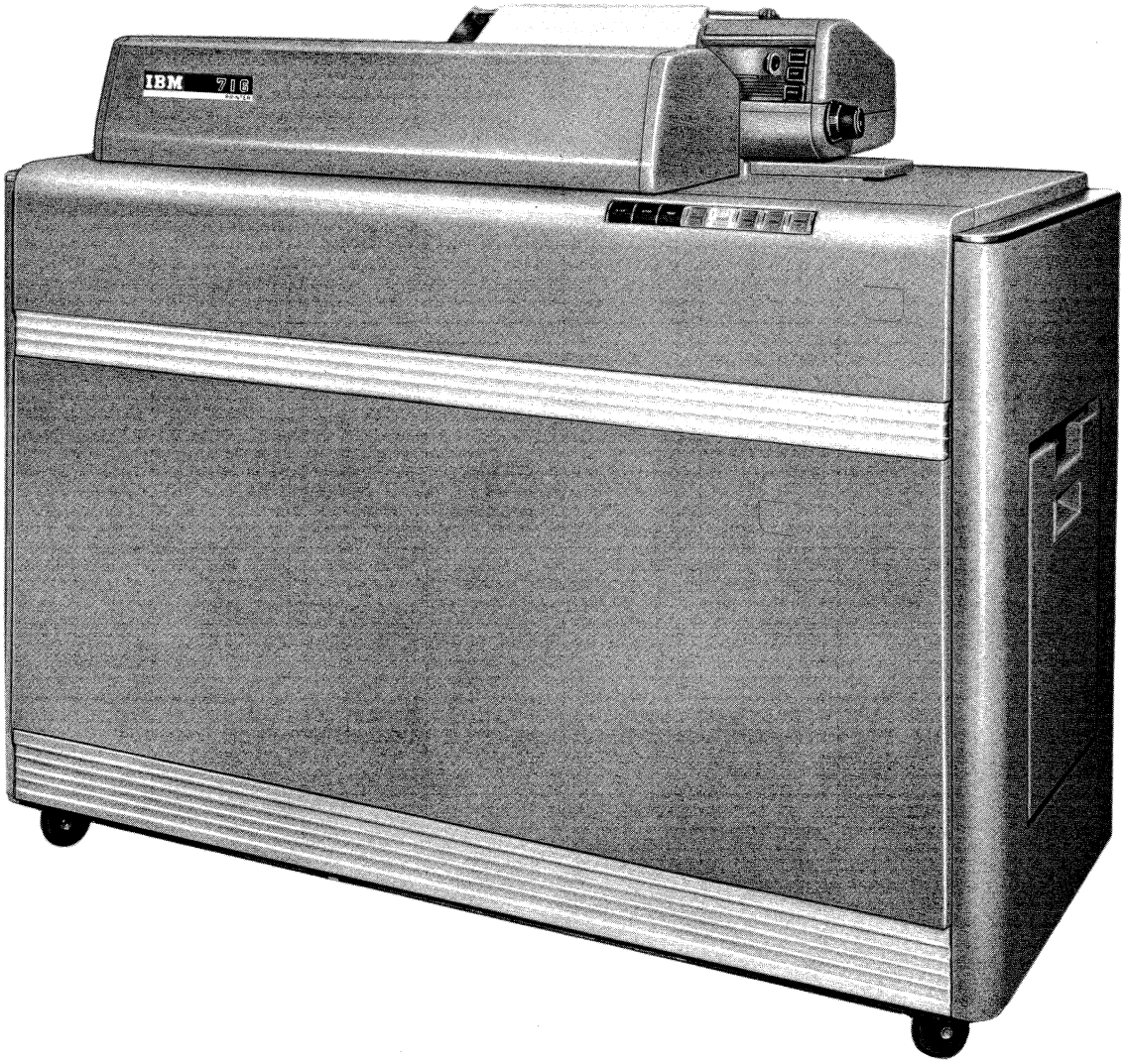
Pilot Selectors

These two-position selectors can be transferred in three ways. Consider pilot selector 1 as an example. The X-PU hub is receptive during X and R time. When a pulse is directed to the X-PU hub of pilot selector 1 control relay, between 180° and

189°, the selector control relay 39 picks. It holds through its 1n/o point and CF12 until 280° of the current feed cycle. At 240° of the cycle, R41 is picked through CF10, R39-2 n/o and R96-1n/o. R41 holds through its 1n/o point and CF9 until 225° of the next cycle.

The D-PU hub of the selector relay 40 may be impulsed any time between 005° and 270°. R40 holds through its 1n/o point and CF12 until 280° of the current cycle. The selector transfer relay, R41, is picked through CF10, R40-2n/o, and R96-1n/o. It is held until 225° of the following feed cycle, through CF9 and R41-1n/o.

A pilot selector may be transferred immediately by an impulse into the immediate pickup hub. The selector points remain transferred until 225° of the cycle during which the transfer relay is energized.



IBM 716 PRINTER

IBM 716 PRINTER

1.0.00 INTRODUCTION

THE IBM 716 Printer is an "on line" printer output used with several computer systems. Such an output is desirable for visually checking the operation of a program by the system, or for immediate recording of system compilations. Operation of the 716 printer as an independent machine is not possible.

The printing and drive mechanisms found in the 716 are identical to those of the IBM 407 Printer. The 716 has resulted from the removal of the counters and card feed from the 407, with the necessary circuit modifications. The capacities of the 716 printer are the same as those of the 407, including printing at the rate of 150 lines per minute in a possible 120 positions. The 922 carriage is employed, and only its control circuitry has been altered.

Knowledge of the 407 printer is assumed in the preparation of this text. Information common to 407 operation will not be stressed but may be mentioned for purposes of review.

The 716 printer performs two functions in addition to printing. One is to provide 40 and 55v powering for the card punch and card reader. The other is to provide the data path from the reader and punch to the system employing them. It is not possible to operate a punch or reader without using the printer.

2.0.00 FUNCTIONAL PRINCIPLES

2.1.00 PRINTING CAPACITY

There are 120 alphabetic-numerical type wheels in one solid section. Each type wheel consists of a complete alphabet, all numerals, and 12 special character positions (Figure 2.1-1). Deviations from the 12 special characters shown may be obtained by a customer. On the basic wheel there are two asterisks (*), two plus signs (+), and two minus signs (-), making 9 different special characters on each type wheel. A total of 48 characters is located on each wheel. All characters on the type wheels are available for printing during all print cycles.

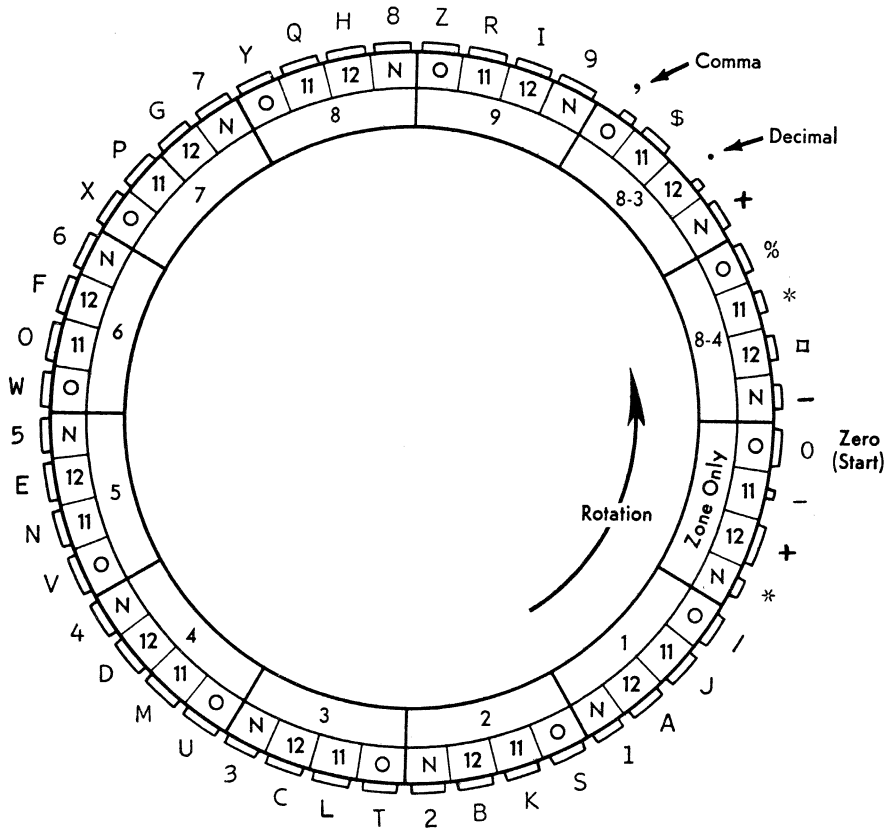


FIGURE 2.1-1. TYPE WHEEL SCHEMATIC

2.2.00 TYPE WHEEL SPACING

Each type wheel utilizes a .1 inch lateral space. There are 10 spaces to the inch, and the entire printing section requires 12 inches.

2.3.00 ZERO PRINT CONTROL

Zero printing and certain special character printing is under control of the zero print control hubs. This means that zero printing is under the control of electrical circuits. No wiring of these hubs is necessary for alphabetic printing. All hubs of a group, except the highest order position, are wired together for printing numerical information.

2.4.00 CHARACTER EMITTER

Printing of any prearranged descriptive information is under control of a character emitter that includes all alphabetic, numerical, and special characters. This feature may be used to describe sheet overflow designations or groups of printed information.

2.5.00 SELECTOR CONTROLS

Pilot Selectors

Ten pilot selectors are available for controlling spacing, skipping, or co-selector pickup. Pilot selector pickup may be controlled from the alternation switches, print cycles, character emitter, or sense exits. The pilot selector transfers for the print cycle following the cycle during which it is picked. Coupling exit hubs are provided to be used with co-selectors for increasing the capacity of a pilot selector. Each pilot selector has two sets of controlling points.

Co-Selector

Co-selectors that may be coupled with pilot selectors for an increased number of controlling points are available. They may be picked up by any impulse and will remain energized until the end of the operating cycle. Each co-selector has five sets of controlling points.

2.6.00 ALPHABETIC PRINTING

A single wire connecting a calculator exit hub or an alphabetic character emitter hub to print entry is required to control the alphabetic printing.

2.7.00 TAPE-CONTROLLED CARRIAGE

The printer is equipped with an automatic carriage that controls the platen. It serves as a standard carriage, advancing the paper by single or double line spacing under control of the space switch (on the control panel); it may also be controlled to advance the paper automatically for various distances under control of a tape.

Operation of the carriage is flexible, taking place under control of the tape and wired controls on the control panel. Ten channels are provided to control the predetermined printing positions; thereby providing for a number of groups within a form and maintaining the form in proper step in the event that some section of the form is to be left blank. It will accept single sheets or continuous forms, and provides complete flexibility in advancing continuous forms from sheet to sheet, and from section to section within a single sheet.

All continuous form lengths for use in the carriage must be in multiples of 1/6 inch. The tape takes care of a maximum sheet length of 22 inches. Various sheet widths up to a maximum of 16-3/4 inches may be accommodated by the carriage.

3.0.00 MECHANICAL PRINCIPLES

3.1.00 LOCATION OF PARTS

Figure 3.1-1 shows a front view of the machine with the covers off. All relays are located on the single gate shown. These relays are numbered on both front and rear to facilitate working on the relay gates.

The print mechanism is located at the upper center section of the machine. Immediately to the left of the print mechanism is the variable speed drive, used to control the speed of the printing mechanism. Also in this area but more to the front is the magnetic clutch. This clutch, which controls the operation of the machine, has no adjustments to be maintained. It allows the machine to idle when not in use and prevents excessive wear on shafts, gears, and bearings. The Bijur oil pump is located just in front of the magnetic clutch.

Figure 3.1-2 shows the rear view of the machine with the covers off. The CR and CF circuit breakers are pointed out. The CF cams are under control of the CF cam clutch. The CF cams must operate for printing to take place; therefore, the CF cam clutch must be engaged for each print cycle. The CR cams operate on all machine cycles. The CF cam clutch is necessary to insure that certain selector and control relays are held energized while the printer is waiting for the next read or write printer instruction, and to insure that some circuits will function only during a print cycle.

The motor and generator are located at the lower right. The printer generator supplies 46v to the printer.

The cable connectors are shown at the lower left. The connectors are numbered from left to right, top to bottom (looking at the rear of the machine).

The dynamic timer indicator is located at the top of the vertical shaft.

The left end view of the printer with the covers off (Figure 3.1-3) shows the fuse panels, the dynamic timer and power supplies, and the convenience outlet. The carriage speed resistor and voltage resistor are also shown. The fuses are numbered from right to left (looking at the left end of the machine).

Figure 3.1-4 shows the rectifier and rectifier transformers. The printer rectifier supplies 55v to printer, card reader, and card punch thyratron plate circuits.

3.2.00 DRIVE MECHANISM

A schematic of the drive for each unit of the machine (Figure 3.2-1) shows the relationship between the various units and how each unit is controlled.

When the printer line switch is on, the motor and generator, and the drive pulley, belt, and magnetic clutch pulley (clutch armature), are operating. For a print cycle the CF cam clutch and the magnetic clutch are energized; therefore, all the units shown are operating.

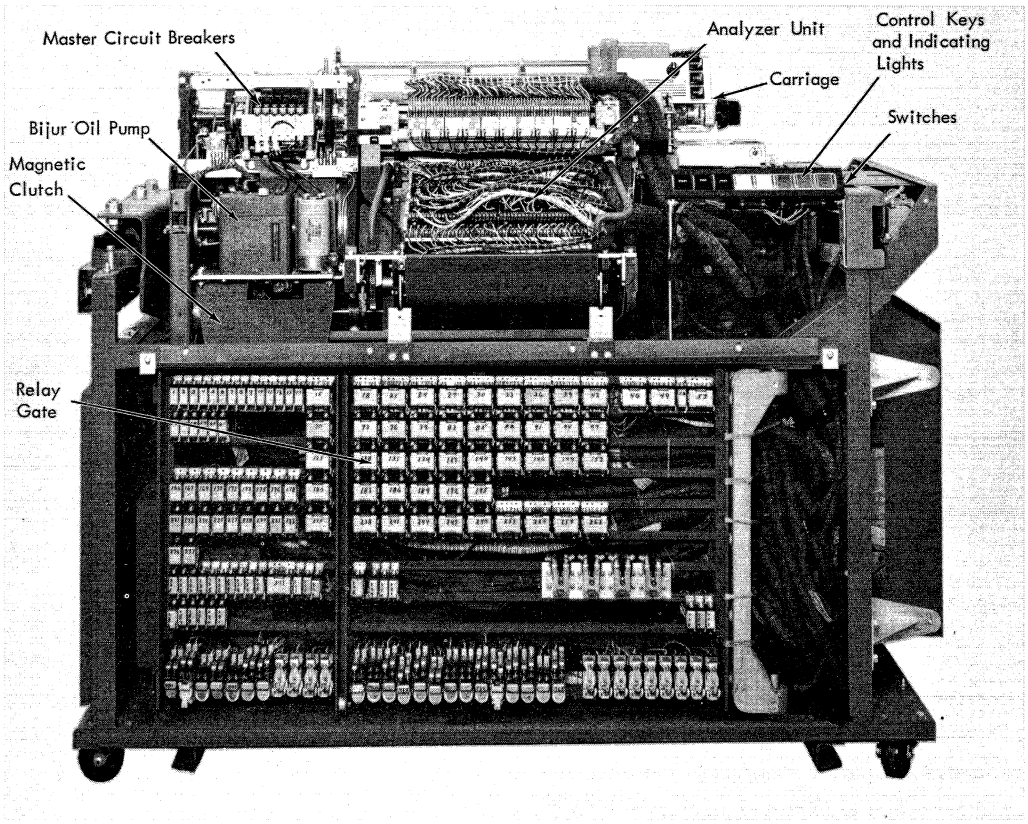


FIGURE 3.1-1. FRONT

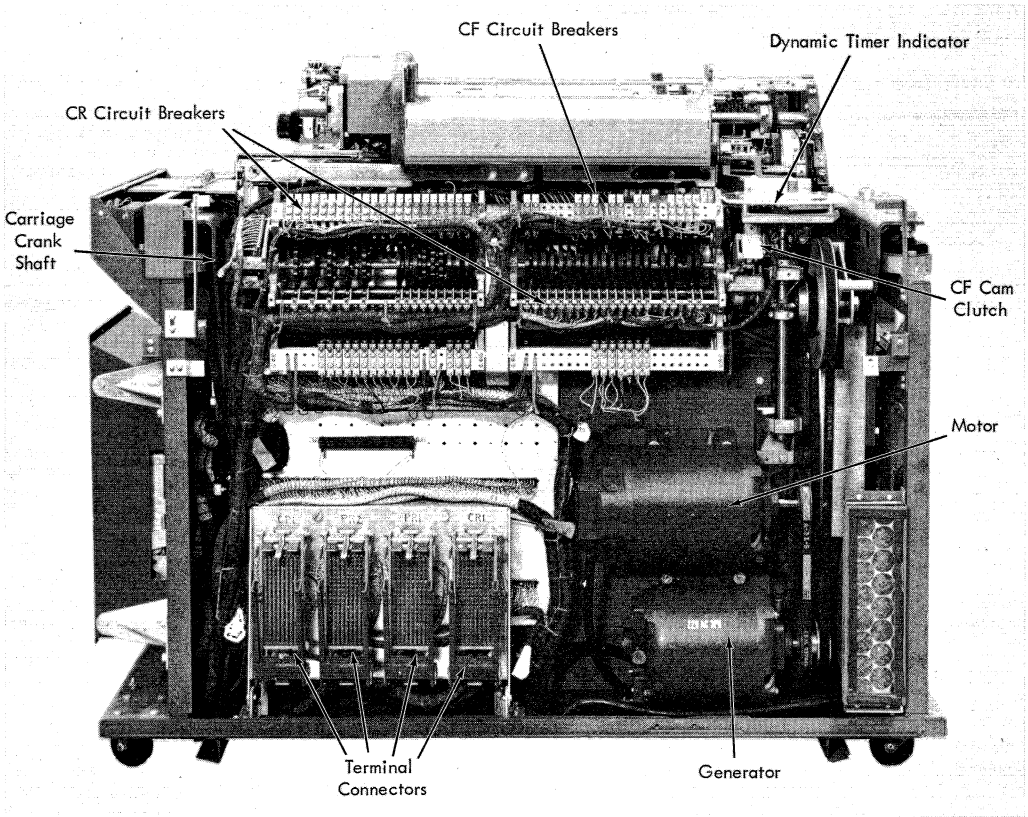


FIGURE 3.1-2. REAR

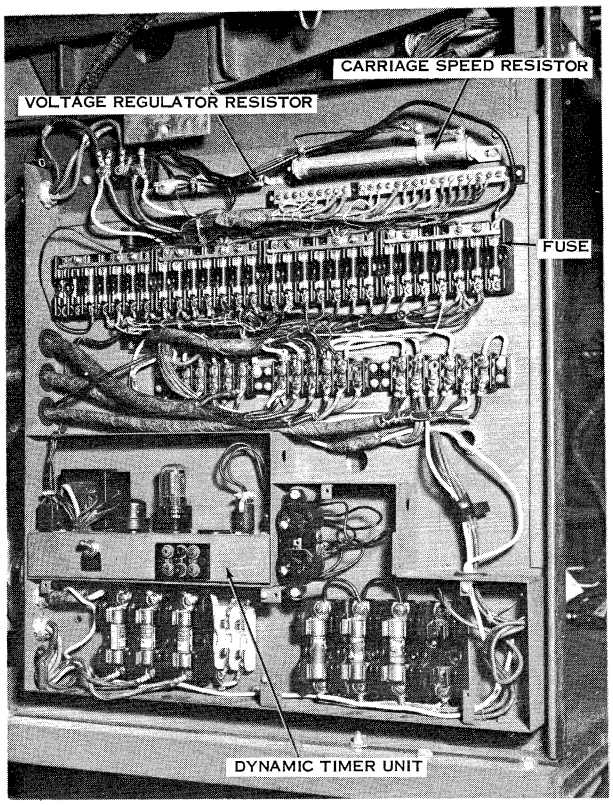


FIGURE 3.1-3. LEFT END VIEW

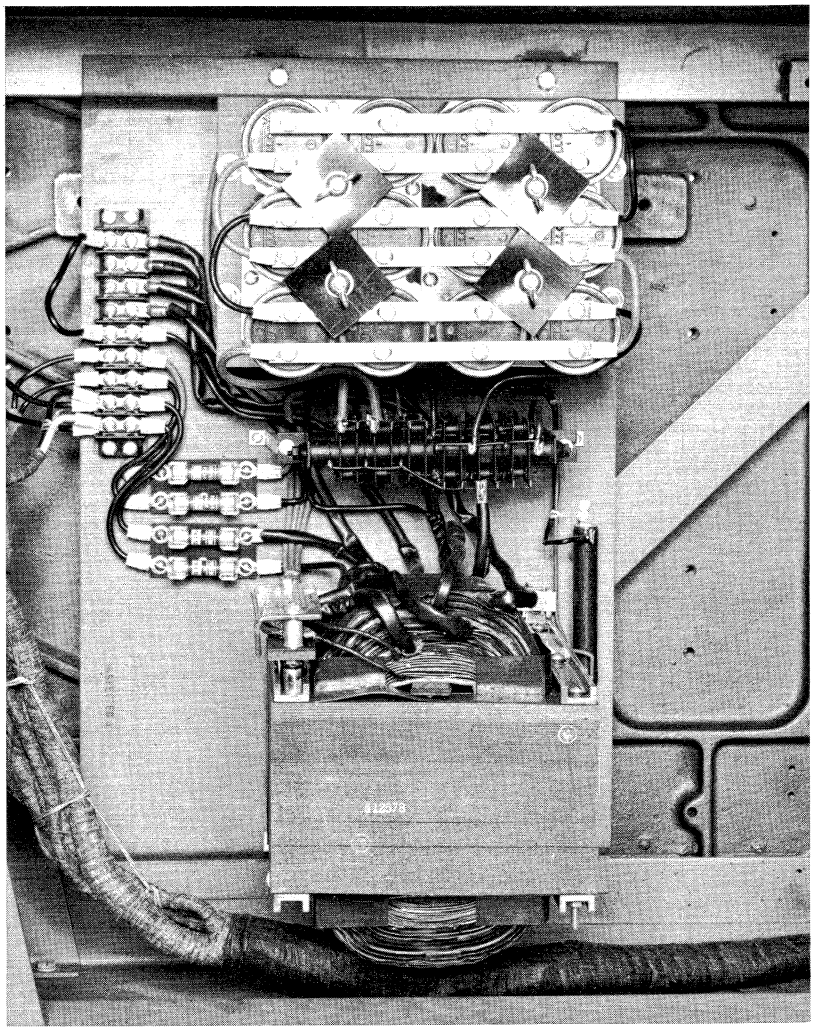


FIGURE 3.1-4. 55 VOLT SUPPLY

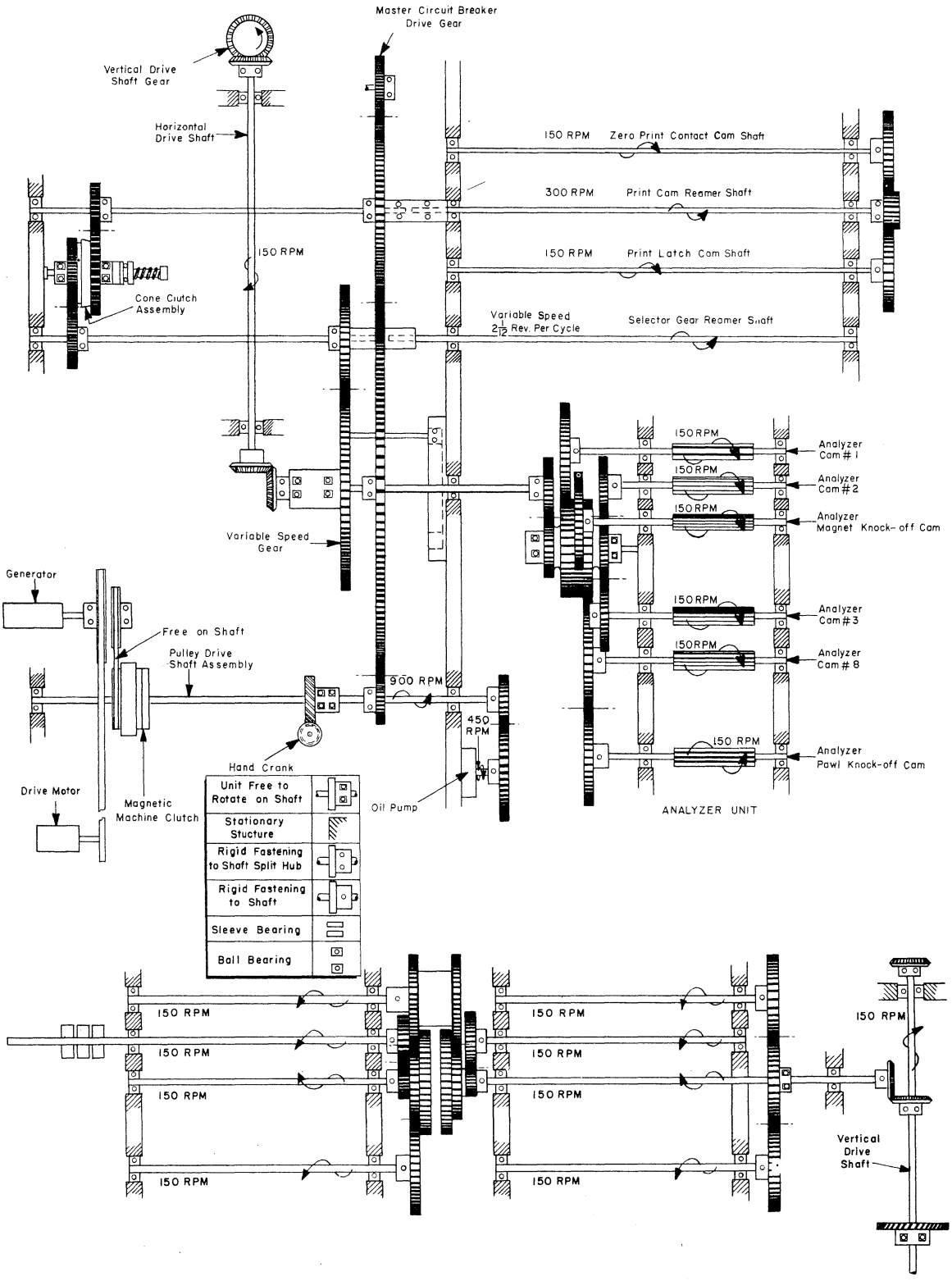


FIGURE 3.2-1. MECHANICAL POWER SUPPLY

3.3.00 MAGNETIC CLUTCH

The printer is under control of a magnetic clutch. The motor, the generator, and the clutch pulley are the only elements operating when the printer line switch is on and a print cycle is not being performed. One of the operations performed as a result of a read or write printer instruction is the energizing of the magnetic clutch magnet.

3.4.00 PRINT MECHANISM

Printing by the 716 is performed by the type wheel print mechanism. The print mechanism prints 120 alphabetic or numerical characters at the rate of 150 lines per minute. The type wheels are positioned to print ten characters per lateral inch. Each of the 120 printing positions is capable of printing forty-eight characters: ten numerical characters, twenty-six alphabetic characters and twelve special symbols. The numerical and alphabetic characters are selected by proper conditioning of the calc exit hubs or by impulses from the character emitter. An 8 and a 4 impulse or an 8 and a 4 in combination with each of the zone impulses 0, 11, and 12 provides four different symbols. An 8 and a 3 alone or in combination with each of the zone impulses provides four more symbols. By using the 0, 11, and 12 impulses alone, three more symbols can be obtained; by using the N impulse (no zone impulse, available on each machine cycle), one more symbol can be obtained, making twelve in all. See Systems Figure 12-1 for the individual codes. Several other entry and exit hubs used to print certain symbols are covered in the circuits section (5.0.00).

3.5.00 VARIABLE SPEED DRIVE

The printer is equipped with a variable speed drive for changing the speed of the selector clutch reamer shaft within one machine cycle. During the selection of impulses 1-9 and the engaging of the selector clutch, the selector clutch reamer operates at 300 rpm. At this speed four type positions pass through a point every 15^{o} or for the movement of one flute of the reamer. After the print clutch dog is engaged and the print cam reaches printing time, the selector clutch reamer slows down to 75 rpm, which is one-quarter of the speed at selection time. Because there are four possible places for the print clutch dog to engage with the print clutch reamer, and since the selector gear and type wheel have slowed down to one-quarter of their normal speed, printing takes place in one of four places corresponding to the slot of the selector clutch reamer into which the selector clutch dog is engaged. The four characters in position to print will be the ones using a common lower punch, such as V, N, E, and 5. All of these characters depend on a 5 impulse during selection time. The particular character that does print depends upon the flute of the print clutch reamer in which the print clutch dog is engaged.

3.6.00 CONE CLUTCH

The cone clutch is a mechanical arrangement to connect two shafts by one common mechanism at a specified time. The clutch is not under control of a magnet and is entirely mechanical. This clutch assembly is used to connect the print clutch drive shaft and the selector clutch drive shaft to remove any play between the shafts; it also acts as a brake on the selector clutch shaft in reducing its speed to one-quarter speed just before printing takes place.

3.7.00 RIBBON FEED

The ribbon feed on the 716 operates only when the carriage spaces. If the ribbon were fed constantly, much of the ribbon would be in good condition and other sections would be unusable. Feeding the ribbon only when carriage spacing takes place eliminates uneven wearing of the ribbon.

A clutch is provided to allow the ribbon to feed only on carriage spacing operations. This clutch is controlled by the machine circuits to be operative only when carriage spacing takes place.

3.8.00 CR AND CF CIRCUIT BREAKER ASSEMBLY

The circuit breaker assembly consists of CR (continuously running) circuit breakers which operate on all cycles, and CF (card feed) circuit breakers which operate on print cycles.

The CR cam shaft is connected directly to the vertical drive shaft and operates on all cycles. The CF cam shaft is connected to the vertical drive shaft through the card feed cam clutch. This clutch is under control of the CF cam clutch magnet. Until this magnet is energized, the CF cams do not operate. These cams latch at 345°; this is the basis of the timing of a print cycle.

If the circuit breaker assembly is viewed from the rear of the machine, the upper right unit is the CF cam unit. The gear on the CF cam shaft is free; therefore, the turning of this gear, which receives its motion from the gear train, does not cause the CF cams to turn. The CF cam clutch assembly causes the CF cam shaft to turn. The clutch dog which is attached to the clutch dog arm, becomes engaged with the one-tooth ratchet that is part of the continuously turning gear. Since the clutch dog arm is pinned to the CF cam shaft, the CF cams operate whenever the clutch dog becomes engaged with the one-tooth ratchet. The clutch dog is controlled by the CF cam clutch magnet armature. Consequently, on all cycles on which the CF cams are to turn, the CF cam clutch magnet must be energized.

4.0.00 CIRCUIT DESCRIPTION

4.1.00 POWER SUPPLY

The printer contains the 40 and 55v supplies for the card punch, card reader, and printer. The generator furnishes power to the start and running circuit relays and control relays. The rectifier furnishes voltage for the sense thyratron, write thyratron, selector thyratron, and disconnector thyratron plates, and for the key trigger grid inputs.

The generator is normally set for 46v at no load, and the rectifier produces 60 to 65v at no load.

The supplies are available in the three units when the printer line switch is on and the DC power is on in the power distribution frame.

4.2.00 WIRING DIAGRAM

The card machine power supply and the printer and 922 carriage relay circuits are shown in Systems sheets 1 through 6. All points and contacts are shown as they would be with power off in the machine and the CF cam clutch in its latched position. Systems sheets 8 through 10 show the locations of the relay coils and points and give a description of the relay. The size and type of each relay are also listed. Systems sheets 11 and 12 list the CF and CR cam numbers, locations, names, part numbers, styles, make times, break times, and tolerances in degrees. Systems sheets 11 and 12 also contain electrical timing charts showing the make and break times of CF and CR cams in relation to the machine cycle.

4.3.00 CONTROLS, INDICATING LIGHTS AND SWITCHES

Start Key

If no printer fuses are blown, the 40 and 55v buses are energized, the paper form and control panel are in place, and the test switch is off, depressing the start key energizes the calculator interlock relay. This puts the printer drive clutch under system control. Depressing the start key also turns on the ready light.

Print Key and Stop Before Printing Switch

If the stop before printing switch is turned on, and the test switch is off, the printer does not print when instructed to by a printer read select or printer write select instruction. When the calculator arrives at the first copy instruction for the line to be printed, it is held up in ER time. If the print key is then pressed, the printer will go through one cycle to print the line, provided the calculator interlock is on. The print key is inoperative when there is no printer read select or printer write select instruction for the printer, or when the stop before printing switch is off.

Print Key and Test Switch

If the test switch is on, pressing the print key causes the printer to go through one or more print cycles until the key is released. For normal operation the switch should be off.

Form Stop Light and Form Stop Switch

When the form stop switch is on and the form in the carriage has nearly come to an end, as determined by the end-of-form stop on the carriage, the calculator interlock is dropped out and the form stop light comes on. The interlock and light are turned off by feeding additional forms into the machine and starting it again. If the form stop switch is off, the form stop feature is inoperative.

Alteration Switches 1, 2, 3, 4

When an alteration switch is on, an impulse is available each print cycle at the corresponding control panel alteration hub. These impulses are used to control selectors.

Stop Key

This key releases the calculator interlock and turns off the ready light. The start key must be depressed to again give the printer drive clutch control to the system.

Select Light

This light indicates that the printer has been selected to read or write. The light is turned off at the beginning of the print cycle.

Fuse Light

When a signal fuse blows, the printer stops and the fuse light comes on.

Power On

This light indicates that the 40 and 55v buses are energized. This means that the printer line switch is on, and DC power in the power distribution frame is up.

4.4.00 PRINTER CONTROL PANEL (Figure 4.4-1)

Overflow (Ovfl) (Section 6B)

Note: Section notation refers to Systems diagrams.

These hubs emit an impulse when the last line to be printed on the form is reached. The position of this line is controlled by the punching of the carriage control tape. If normal form to form ejection is desired, these hubs should be wired to carriage skips hub 1. This causes the carriage to skip to the first line of the next form.

Carriage Skips (Carr Skips) (Section 6A)

There are 10 carriage skip hubs on the control panel representing 10 punching positions (channels) of the tape, 1 through 10. When one of these entry hubs receives an impulse, the carriage starts skipping. The skipping stops only when the next hole in that channel is sensed.

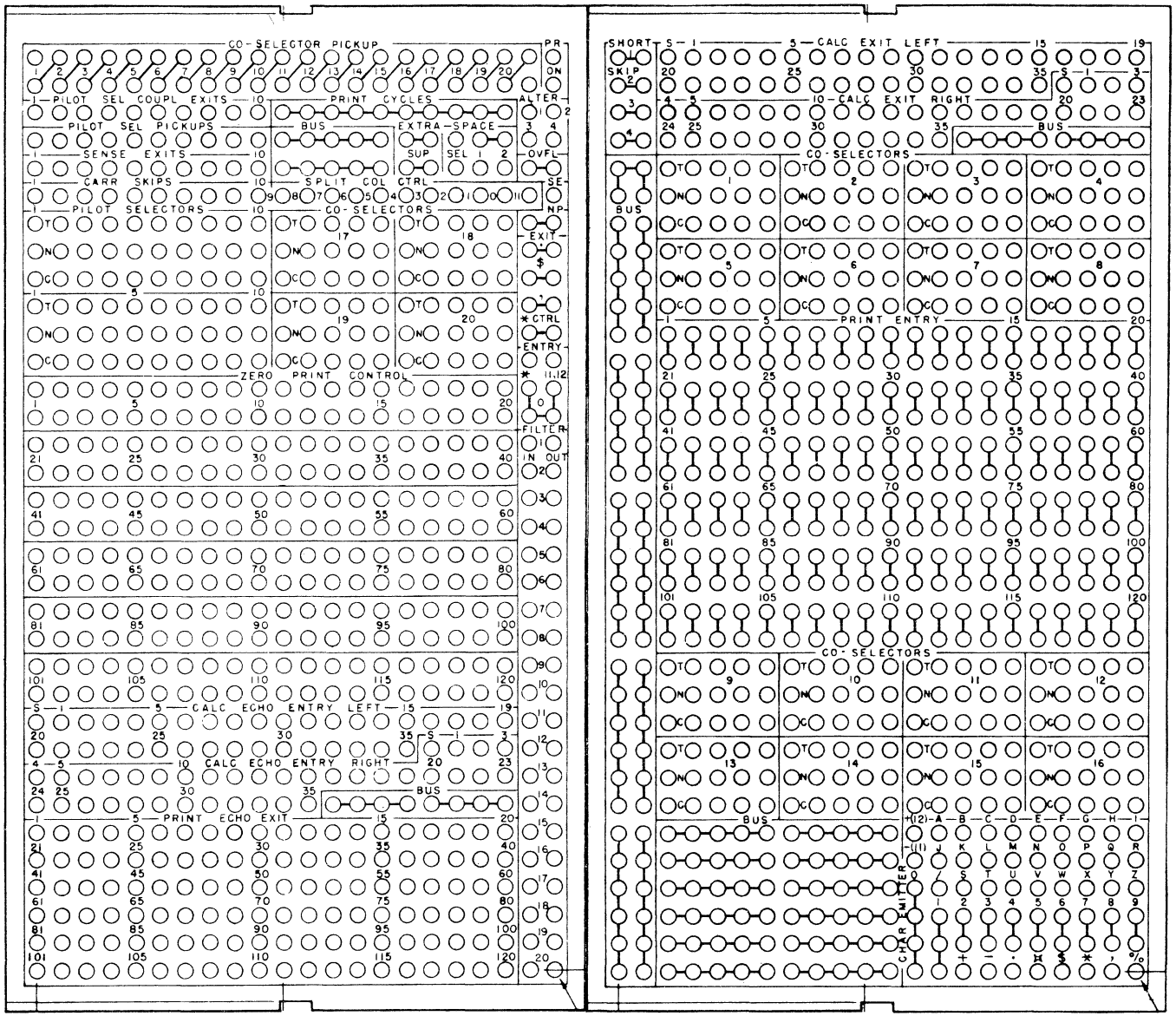


FIGURE 4.4-1. PRINTER CONTROL PANEL

If two carriage skip hubs receive an impulse during the same cycle, the channel corresponding to the lower numbered carriage skip will be effective; the other channel is ignored. For example, if carriage skips 2 and 5 receive an impulse during the same cycle, the carriage will skip under control of channel 2 regardless of where the punch is located in channel 5. The carriage skip hubs are normally wired to sense exits or overflow.

Short Skip (Section 7A)

Normally the 716 is interlocked for one machine cycle whenever a skipping operation is taking place. However, the short skip hubs may be used to prevent interlocking from taking place. When the maximum length of a skip does not exceed two inches, it is not necessary to interlock the machine.

These hubs are normally wired to overflow for operations of less than one inch and to sense exits for skipping operations of less than two inches.

Print Entry (Sections 11A-12A)

The 120 print entry hubs normally complete the circuits to the analyzer magnets for all impulses. They are normally wired from calculator exit left or calculator exit right hubs.

Asterisk Control (* Ctrl) (Section 4A)

These hubs emit an impulse at N time to energize co-selectors for the purpose of controlling the printing of *'s to the left of significant figures.

These hubs are normally wired to co-selector pickup hubs; this control allows the asterisk to print under control of the N impulse and is not the same as the asterisk impulses which come through at 8, 3, and 11 times.

Filters (Section 14B)

These hubs are used to prevent back circuits under certain wiring conditions, such as printing decimals, commas, and dollar signs. The impulses to the filters must go to the entry hubs; otherwise, the circuit will not be completed through the filters (selenium rectifiers).

0-Entry (Section 12A)

These hubs accept a 0 (zero) impulse only. They are used to control the printing of zeros regardless of the presence of significant figures. They are normally wired to the lower hub of zero print control hubs.

Asterisk Entry (* Entry) (Section 12A)

These hubs accept an impulse at N time only. They cause *'s to print in a field even though significant figures are not present. They are normally wired to lower zero print control hubs through selector points. The selector relays are energized by an impulse from the asterisk control hub.

11-12 Entry (Section 12A)

These hubs accept impulses at 11 and 12 times only. They are used to control the printing of the + (plus) or the - (minus) sign to the left of significant figures. These hubs are normally wired to lower zero print control hubs for positions that are to print.

Co-Selector (Section 9B)

Each co-selector has 5 positions. These hubs are connected to the points of the co-selector relays. The T hub represents the transfer point, the N hub represents the normal point, and the C hub represents the common point. Thus the T and C hubs are internally connected when the co-selector is picked up. When the pickup hubs are impulsed, the selector points transfer immediately and remain transferred until the end of the cycle.

Character Emitter (Sections 13-14)

All letters, digits, and special characters are emitted from the character emitter hubs during each machine cycle. These hubs emit impulses according to the code of the character.

Symbol Exits (Section 13B)

Comma. These hubs emit the proper impulses to print commas in any type position. They are not the same type of hub as the comma hub of the character emitter, although both hubs may cause a comma to print in all wired positions on all printing cycles. However, the impulse from the comma (symbol exit) hub may or may not cause a comma to print, depending upon a significant figure to the left of the printing position. See special symbol printing in Section 5.5.00 for methods of eliminating the printing of commas.

These hubs are normally wired to print entry. They emit impulses at 337^{o} and 0 time.

Decimal. Decimal printing is similar to comma printing, explained above. The decimal may or may not print, depending upon the conditions at the time of printing. These hubs are unlike the character emitter hub for a decimal. See special symbol printing in Section 5.5.00 for more details.

These hubs are normally wired to print entry. They emit impulses at 337^{o} and at 12 time.

Dollar Sign ($). These hubs function in the same manner as the commas and decimal hubs described above. The dollar sign ($) may or may not print, depending upon the conditions at time of printing. These hubs are unlike the character emitter hubs for a dollar sign ($). See Section 5.5.00 for more details regarding special dollar sign ($) printing.

These hubs are normally wired to print entry. These hubs emit impulses at 337^{o} and 11 time.

Co-Selector Pickup (Section 9B)

These are the pickup hubs for the co-selector relays. The co-selector relays may be picked up by any impulse. The points are held transferred only during the cycle in which the co-selector relays are picked. The pickup hubs are normally wired from the pilot selector coupling exit.

Pilot Selectors (Section 10B)

There are ten 2-position pilot selectors, each having a normal position and a transfer position.

Pilot Selector Pickup (Section 10B)

Each pilot selector has a single input. The selector transfers at 315^{o} of the cycle in which it is picked. It remains transferred through the following print cycle.

Pilot Selector Coupling Exits (Section 10B)

An impulse is available at the pilot selector coupling exit hubs as long as the pilot selector remains transferred. The coupling exit hubs are normally wired to co-selector pickup hubs.

Alternation Switch (Alter SW) (Section 9A)

These hubs emit an impulse on every machine cycle provided the corresponding alternation switch is on. They are used to change the control panel set-up without changing the control panel wires. These hubs are normally wired to co-selector pickup hubs. The co-selectors in turn are used to change the inputs to any entry hubs.

Split Column Control (Section 9B)

These hubs emit impulses between normal digit impulses; that is, the 9 hub emits an impulse between the normal 9 and 8 times of the master CB pulses. The hubs are normally used to energize selectors for special applications.

Selective Space (Section 7B)

These hubs are used when spacing under control of channel 11. When these hubs are connected directly, the carriage will space according to the punches in channel 11. These hubs may be used in conjunction with a selector to cause special spacing in some part of the form, and normal single or double spacing in the rest of the form.

Space 1-2 (Section 7B)

Space 1 hubs wired together cause the carriage to space one line before and/or after printing, depending upon the type of printing taking place. The upper hubs emit an impulse each time the carriage circuit breaker makes. The circuit through these hubs actually stops the spacing operation after the carriage spaces one line. Double spacing will result from corresponding wiring of the space 2 hubs.

If both of these hubs and the selective space hubs are unwired, spacing continues without stopping. The space 1 and 2 hubs may be selected so that single and double line spacing may be placed under control of a selector.

Extra Space (Section 6B)

An impulse into these hubs before 110^{o} prevents spacing before printing, each cycle that the impulse is received. However, extra space after printing, if wired, takes place regardless of the space suppression operation.

Print Cycles (Section 9A)

These hubs emit an impulse from 355^{o} to 285^{o} of each print cycle.

Zero Print Control (Section 11B-12B)

These hubs are used to control the printing of zeros, commas, asterisks, dollar signs, and decimals. They may be wired to print or not print the above characters, depending upon the conditions at the time of printing.

The method of wiring these hubs determines whether zeros will print to the right or left of significant figures or not print at all. Except for the highest order position, these hubs are normally jackplugged for printing zeros to the right. When printing zeros to the left, the lower hub of the highest order position is wired to the upper hub of the position immediately adjacent to the units position. See Section 5.4.00 for a more detailed explanation of methods of wiring these hubs.

Bus

These hubs have no function except to provide more outlets for the particular function connected to them. Four, five, or six hubs are connected together at several places on the control panel to provide additional outlets when needed.

Print Echo Exit (Section 11A-12A)

Timed impulses are available at these hubs 150^{o} after the print impulses (9 through 1) are sent to the print magnets. Also (8-4) and + (8-3) sign indication echo impulses are available at 120^{o} and 135^{o}, respectively. These exits are normally wired to calculator echo entry hubs. The echo impulses are used to check the printed information.

Calculator Echo Entry Left and Right (Section 19-20)

These entry hubs are wired from the print echo exits. The echo impulses received by these hubs are routed to the system.

Non Print (NP) (Section 7A)

An impulse into these hubs prevents the machine from printing for one cycle. The NP hubs are normally wired from print cycles in conjunction with pilot selectors.

Impulsing the NP hub prevents 0, 11, 12, or N impulses from reaching the print magnets. This prevents the print cams from starting. To insure that no characters are printed, the NP hub should be impulsed early in the print cycle.

Sense Entry (SE) (Section 18B)

The sense entry hub is an input to the system.

Wiring overflow to sense entry only can put overflow operations under control of the system program. Overflow may also be wired to a carriage skip hub and to the sense entry hub. In this case, the printer controls overflow operation, and the pulse to the sense entry hub indicates to the system that an overflow operation is about to take place.

Sense Exit (Section 10A)

The system may cause an impulse to appear at any of the 10 printer sense exit hubs. The sense relays can be energized any time after 4^{o} in a print cycle. The corresponding sense exit hub is hot from 240^{o} to 350^{o}. Sense exit hubs are normally wired to carriage skip hubs.

Printer On (PR-On) (Section 15)

The printer on switch must be wired on and the control panel must be in place before the printer start key is operative.

Calculator Exits Left and Right (Sections 21-23)

The calculator exit hubs are the data input source from the system. The card image impulses are available at these hubs and are normally wired to the print entry hubs.

4.5.00 DYNAMIC TIMER

The printer has a combined index and time dial permanently mounted over the top of the vertical drive shaft at the rear of the machine. The timer disk is held to the top of the vertical drive shaft with two headless setscrews. Two neon bulbs are mounted on the timer disk and serve as pointers as the disk rotates with the vertical shaft. Each neon bulb is supplied with a separate control circuit, making it possible to compare dynamically two separate conditions, such as the duration of an impulse supplied by a cam contact to energize a relay, and the time at which the normally open points of the relay close. This indicates the degrees of machine time required for the relay to pick. Connections are brought from the bulbs by way of a commutator to an amphenol male connector that plugs into a socket on the dynamic timer power pack.

The dynamic timer power pack is permanently mounted on the left end of the machine. Connections are brought from the power supply to the power pack through a male connector that plugs into the power pack.

On the front of the power pack, the index lamp switch is located on the left; the terminal block, for making external connections from the circuit component under test to the power pack, is located in the center.

The index lamp switch is effective only when the power pack on-off switch is placed in the on position 1. The index lamp switch in the on position causes the inner neon bulb to glow, which then serves as an illuminated pointer for the index. This is especially useful when turning the machine by hand and observing the index when lighting conditions at the machine location are poor. With the index lamp switch set to normal, the neon bulbs glow only when an external connection is provided to the power pack.

5.0.00 CIRCUITS

5.1.00 GENERAL INFORMATION

While studying the circuits on the 716, keep in mind the following points:

The analyzer unit and print unit are never latched. They are driven directly from the magnetic clutch and coast to a stop at some indeterminate point.

The running and printing control circuits are controlled by CR and CF cams. The CR cams are always in time with the print unit. The CF cam clutch latches or unlatches at 345^{o}. The CF cams control mainly the printing circuits. The cycle of operation of the CF cam clutch is considered the print cycle. The print cycle, therefore, will be considered from 345^{o} to 345^{o}.

Because the printer magnets receive information in the same order as though a card were being read, they are said to print a card image.

An image of the 9 through 1 impulses is made available at the print echo exit hubs when a printer read select instruction has been given.

5.2.00 START AND SELECT CIRCUITS

Note: Figures in parenthesis refer to Systems Diagram Areas.

When the printer line switch is set to the on position, power is supplied to the printer drive motor and rectifier.

When the printer rectifier output rises, R351 P and H coils are energized (18A). R351-3n/o closes and, if the power supply interlock is closed and the printer generator output is up, R445 will pick and the power-on light will come on (17A). With R445 up, HD 1, 2, 3, and 4 (17A) come up and DC is supplied to the printer, punch, and card reader DC buses. (1A).

R445B closes the start key circuit (3B). Before the start key is operative, the printer on switch (15A) must be jackplugged and the control panel must be in place.

When the start key is depressed, the calculator interlock relay, R386 (4B), becomes energized, provided a fuse is not blown, the power-on relay is up, the form stop relay is down, the control panel is in place, the test switch is off, and the stop key is not depressed. The ready light comes on at the same time that R386 is energized (4B). R386 remains energized and holds the printer in the ready status until the stop key is depressed, the test switch is turned on, the control panel is removed, the form stop relay is energized, power is turned off, a fuse blows, or the carriage stop key is depressed (3B). When one of the above mentioned conditions exists, the calculator interlock relay becomes de-energized and the printer magnetic clutch is no longer under control of the system.

After the printer is made ready, it waits for a printer read select or printer write select instruction to initiate a print cycle.

Concerning printer circuits, the only difference between printer read and printer write is that a printer read select instruction causes the type wheel contact isolation control relays to be energized in addition to the printing isolation control relays.

Write Printer

The printer CF cams latch at 345^{o}. The prepare to write relay, R387 (15B), can be energized while the printer is stopped and ready, or any time after 4^{o} of a print cycle. The circuit is from TL3, through CF35, to the systems, and returns to R387. R387-1 turns on the select light (4B). The light remains on until 354^{o} of the print cycle. R387-4 permits the printer isolation control relay, R447 (5A) to become energized before the print cycle is initiated. R447 holds through its AU point and the n/c points of R440 (5A) until 315^{o} of the print cycle. R447 BU picks R439, the write trigger reset control relay (5B).

R387-2 closes the circuit to R442, the drive clutch relay (4A). R442 holds through CR29 until 290^{o} of the print cycle.

R442BU picks R441, the idling control relay (2A). R441B points energize the 40v secondary bus (1A).

The drive clutch is energized through R441AU (2A).

This sets the print unit, analyzer unit, and CR cam shafts in motion. When CR28 makes at 305^{o}, R388, the auto-start relay (4A), picks through CR28 and R442AL. R388 holds through CF27 until 245^{o} of the print cycle. At 320^{o}, the CF cam clutch magnet (4A) becomes energized through CR26 and R388-3. The CF cams start to rotate at 345^{o}.

If the instruction is read printer select, the start circuits are the same as for write printer select. The type wheel contact isolation control relay, R446 (5A), is picked along with R447; R438 (5B), the read trigger reset control relay is picked in addition to R439, the write trigger reset control relay.

The printer can be selected any time after 4^{o} of a print cycle. The circuit is from TL3, through CF35, to the system, and returns to the prepare to relays. The relays remain energized until 354^{o} of the cycle. CF35 makes again at 4^{o} of the print cycle so the printer may be selected again, if a disconnect occurs at 9 time.

If the printer is to run continuously, a select instruction should cause selection by 295^{o} of a print cycle.

5.3.00 PRINTING

In this section the general operation of printing will be considered. The circuitry involved in zero control, special character printing, and obtaining the impulses (card image) from the system will be discussed in later sections.

General

The print magnet is energized at least twice, three times if alphabetic information is being printed, and four times for some special characters. The first impulse, with the exception of zone impulses, causes the selector clutch gear to start operating at a

definite time, depending upon the time the print magnet receives the impulse. The selector clutch gear does not start to operate immediately after the first impulse is received by the print magnet; the analyzer unit performs a delaying action in case two lower punches are to be read. Later in the cycle zone impulses or the N impulse, depending upon whether it is alphabetic or numerical information, again energize the print magnet, causing the print cam clutch to become engaged and the print cam to revolve. The last impulse in each case is the N (no zone) impulse, which may or may not affect the operation of the print mechanism. If both the selector clutch gear and the print clutch gear are in operation at the time the N impulse is received, the impulse has no effect. The N impulse may affect the print clutch or the selector clutch or both.

The exception mentioned above, for the zone impulses only, causes slightly different operation. The 0, 11, and 12 impulses do not latch the analyzer slides and consequently do not cause the selector clutch gear to operate. However, the print cam will start operating as a result of any zone or N impulse. When the N impulse is received, the analyzer slide 8 is latched and causes the selector clutch gear to operate.

Note that the N impulse comes through automatically on all printing cycles if the print magnet has been energized previously, indicating printing in that type wheel position. There are exceptions to this, as in the printing of zeros. If the proper analyzer slides have not previously been latched, causing the selector clutch gear to operate, the impulse received at N time causes anlayzer slide 8 to be located and subsequently causes the selector clutch gear to operate. If, however, the selector clutch gear is operating by the time the N impulse comes through, there is no effect.

OXRC Relays (4B)

The OXRC relays are energized during O, X, and R time only. These relays are used to control the circuits for printing zeros and special characters. They also have a special function when printing asterisks to the left of a field.

OXRN Relays (4A)

The OXRN relays are energized during O, X, R, and N time. These relays place the circuits to the print magnets for an O, X, R, or N under control of the control panel wiring if the zero print contact has not been previously transferred. This condition is present if no lower punch impulse (9 through 1) is received by the print magnet, but a zone or N impulse is received. The n/c points are used to complete the circuit to the print magnet for 9 through 1 impulses. In the case of printing a letter, the fact that the print magnet is energized by any 9 through 1 impulse causes the zero print contact to be transferred before the O, X, or R impulse is received, and allows the circuit to be completed to the print magnet the second time through the n/o points of a zero print contact.

N Relays (4A)

In series with the print entry hubs (11-12) are the n/c N relay points. These points are used to transfer the circuit going to the print magnets from the print entry hubs to CF cams 30 and 31 for an N (no zone) impulse. When the N relay becomes energized, a circuit at N time is completed to the print magnet to make the print cam operate and cause a number to print, if any 9 through 1 impulse, but not a zone impulse, had previously been received. The N relays, as the name implies, are energized only after 12 time if printing is to take place.

The N relays are also used to control the printing operation. If printing is not desired, the N relays are energized during 0, 11, and 12 time and are not energized during the time of the N impulse. The reverse condition is true if printing is desired. During printing, the N relays are not energized during the 9 to 12 time and are energized during the time of the N impulse. The N relays are under control of the print and non-print relays to allow printing, depending upon the control panel wiring.

Zero Print Contacts (11B)

The zero print contacts, which are operated by the print control contact arm, are in the print magnet circuit. These contacts are transferred when the circuit is completed through the print magnet, except when the print magnet is energized at 337^{o} for printing the special symbols (comma, decimal, or dollar sign) with significant figures. At all other times that the print magnet becomes energized, the zero print contacts are transferred. As explained previously, the print magnet receives at least 2 impulses for each printing operation. The first impulse to the print magnet is completed through the n/c side of the print contact, provided the impulse is during 9 through 1 time.

Subsequent impulses during the same cycle and through the same print magnet are completed through the n/o points of the zero print contact and control panel wiring. The zero print contacts close on the n/o side before the n/c side opens, providing for a continuous circuit to the print magnet as long as the master circuit breakers are making contact, which is for a duration of 9^{o}.

Print Magnet Circuits for Printing Numerical Figures

When the N relays are under normal control, the circuit to the print magnet is as follows: from the master CB (15A), through the write thyratron to the calculator exit hub (21-22), through a control panel wire to a print entry hub (11-12A), through the n/c N relay point, the print magnet, the n/c zero print contact, and the n/c OXRN contact, to the fuse. This causes a selector clutch gear to start turning at the proper time for printing a digit (9 through 1). The zero print contact is transferred when the print magnet is energized. The n/o side closes before the n/c side opens, thereby, keeping the print magnet energized during the transferring of the contacts. After the zero print contacts are transferred, the circuit to the print magnet is completed through the n/o points of the OXRN relay.

When the zero print contacts transfer, they remain in the transferred position until they are relatched mechanically by the zero print contact cam.

The print cam is not affected by the above circuits. An automatic N impulse causes the print cam to start operating, provided an O, X, or R impulse has not previously been received, and provided also that the zero print contact had been transferred by the time the N impulse is received. The circuit for the N impulse is as follows: from TL2 (15A), through the master CB's, CF30 or 31 (11A), R453AL or BU, the n/o N relay point, the print magnet, and n/o print contact point, to the fuse. When the print magnet becomes energized during this part of the cycle, the print cam starts to rotate and operates against the type wheel hanger, forcing the type wheel against the platen.

Print Magnet Circuits for Printing Alphabetic Characters

If the alphabetic character is being printed, the lower (9 through 1) impulse follows the same circuits as when printing a number. This causes the selector clutch gear to start turning at the proper time. Before the N impulse comes through, a zone impulse

is received by the print magnet because an alphabetic character is to be printed. The zone impulse has the same circuit as the 9 through 1 impulse with the exception of the zero print contacts. The zone impulse goes through the n/o zero print contacts to the fuse, because these contacts are transferred when the first (9 through 1) impulse is received by the print magnet. Energizing the print magnet at zone time causes the print cam to operate and print the proper character.

The N impulse comes through at the usual time, but has no effect on the operation of the print unit since the lower impulse caused the selector clutch gear to operate, and the zone impulse caused the print cam to operate.

5.4.00 ZERO PRINT CONTROL

When it is desired to print each zero impulse received by the print entry hubs, the zero control hubs (4A) are not jackplugged. This means that the OXRN relays are transferred only during N time.

Under these conditions, any zero or special character is printed according to the impulses received, and cannot be controlled.

When it is desired to print zeros or special characters under control of control panel wiring, the zero control hubs must be jackplugged.

The following discussion assumes that the zero control hubs are jackplugged.

Zeros may be controlled to print when a significant digit appears to the left, if any significant digit appears to the right or left, or regardless of significant digits. Many special characters are also under control of the zero print control hubs.

OXRC Relays (4B)

The OXRC relays are used to transfer the print magnet circuit (through control panel wiring) to the zero print contact of the adjacent positions to the left during 0, 11, and 12 times. This implies that there was no significant digit present in this position, but that there was a significant digit to the left. In this manner, zero printing may be placed under the control of adjacent printing positions.

Assume that 50 is to be printed in type wheel positions 1 and 2 (11B). The zero print control hub 2 must be jackplugged as well as the normal wiring for standard printing. The circuit to the print magnet 1 is completed in the usual manner explained in the preceding section. The fact that the print magnet 1 is energized at 5 time means that the zero print contact 1 will be transferred at 5 time and remain so until 283^{o}.

When the zero impulse comes through in the second position, the circuit is not completed through the R125-2n/c point (11B) as it would for a significant digit because R125 is energized before the zero is sensed; that is, before the zero impulse is received from the system. The circuit set up for the zero impulse is as follows: from print entry, through R15-2n/c, print magnet 2, the n/c side of the zero print contact, R125-2n/o, the zero print control hubs (which are jackplugged), R70-1n/o, and the n/o side of the print contact for position 1, to fuse 13. Energizing the second print magnet at zero time causes the print cam to operate and force the 0 type face against the platen.

The above shows that the circuit to the second print magnet for the zero impulse goes to the transferred zero print contact of the first position. This indicates it is necessary under normal conditions to set up a significant figure to the left of a zero before the zero will print. For this reason, no zeros are printed to the left of a significant number under normal conditions, even though the zero print control hubs are wired for these positions in the usual manner.

As noted by referring to the mechanical timing chart, a zero impulse does not latch any analyzer pawls. Consequently, the selector gear does not operate for a zero impulse alone. The N impulse, which comes through on all printing cycles, latches the analyzer pawl 8, which in turn causes the selector gear to operate. The movement of the selector gear, in the case of printing a zero, begins the same time the print cam operates against the type wheel hanger. However, the movement before printing is sufficient to keep the zero in alignment while printing.

The circuit to energize the print magnet when the N impulse comes through, which in turn causes the selector gear to operate to position the zero for printing, is as follows: from CF30 and 31, through R453AL, R15-2n/o, print magnet 2 and the n/o side of the print contact, to fuse 13. The zero print contact 2 was transferred when the zero impulse energized the print magnet. All normal impulses to the print magnet cause the zero print contact to transfer. The exception to this is the symbol impulse which comes at 337^{o}.

The above circuit causes the print magnet to be energized at the proper time to latch analyzer pawl 8, which in turn causes the lower operating link to operate against the selector clutch and causes the selector clutch to unlatch. If more than one position is to be printed with zeros at one time, parallel circuits are set up through the individual control panel wiring for each position and through the first transferred zero print contact going from right to left. In the case of printing 5000, three parallel circuits are completed through the control panel wiring of the zero print control hubs for the type wheels printing the zeros and the transferred zero print contact of the position printing the 5. The zero print contacts for the three right positions have not been transferred at the time the zero impulse is received; therefore, the n/c points complete the circuit to the zero print control hubs and to the print magnet to cause the print cam to operate.

Energizing the print magnet at zero time causes the zero print contacts to transfer. The transferred point completes the circuit at N time to the print magnet again, which in turn causes the selector clutch gear to operate. A number of zeros can be printed, to the right of a significant figure if the zero print control hubs are wired for the positions in which zeros are desired, and if a zero impulse is received in each such position.

As in the previous case, the N impulse completes the circuit to the print magnets through the n/o side of the zero print contacts and causes the selector clutch gear to operate. The selector gear must operate to position the type wheel for printing zero. The first impulse (zero impulse) to the print magnet in the above case causes the print cam to operate.

As long as the zero print contact remains in the n/c position, the circuit through the print magnets is not completed for O, X, R, or N impulses. If one contact is transferred, the circuit to the fuse side is complete for any following impulse for that cycle. Through the control panel wiring for the zero print control hubs, the circuit may be completed for adjacent positions.

Printing Zeros to the Left

There are conditions when it is desirable to print zeros to the left, especially in cases of decimals such as .05 or code numbers such as 00052. However, if no significant number appears in the field, it is desirable, in most cases, to leave the field blank. The wiring of the control panel controls the above conditions. To cause zeros to print to the left only when significant figures appear, the zero print control hubs for all positions except the highest order position are coupled together in the normal manner, as noted above. The lower hub of the highest order position should be wired to the zero print control upper hub of the position immediately to the right of the units position.

When printing decimals, zeros are needed only to the decimal, not to the highest order position. In this case, the decimal position is wired to the upper hub to the right of the units position.

Assuming a 05 is being printed, the circuit to energize the tens position print magnet for a zero impulse is as follows: the zero impulse comes into the print entry hub, through R15-1n/c, print magnet 1, the n/c point of the print contact 1, R125-1n/o, the lower zero print control hub, the control panel wire, the upper zero print control hub of the position to the right of the units position, R70-2n/o, and the n/o print contact of the units position, to fuse 13.

This circuit causes the tens position print magnet to be energized at zero time and the print cam clutch to be engaged. The selector clutch gear, however, does not operate as a result of the above circuit. As in the previous cases mentioned, the N impulse to the print magnet is necessary to cause the selector clutch gear to operate. This circuit is identical to the previous N circuits that go through CR cams 30 and 31 and the n/o side of the zero print contacts transferred by the zero impulse. When the amount to be printed is greater than two digits, the zero print control hubs for all positions, except the highest order position, are wired together as in any normal operation. The zero print control lower hub of the highest order position is wired to the zero print control upper hub of the position immediately to the right of the units position. This causes parallel circuits through each of the n/c zero print contacts, and through one or more n/o contacts.

On some occasions, it is desired to print a zero in all positions. The control panel can be wired to satisfy this condition. At the same time, the printing of zeros to the left is also accomplished. In other words, all positions without significant numbers will have zeros printed, even to the extent of having all zeros. A group of zero entry hubs is provided to print zeros for the above conditions. These hubs are connected directly to the fuse side through a cam that is closed during zero time of the cycle.

A caution to be observed is this: care should be taken that the zero entry hubs are not wired to a hub connecting to the line side through some low resistance. These zero entry hubs should be wired to the lower zero print control hub of the highest order position in which zeros are to print. The remaining zero print control hubs are wired together in the usual manner. With this wiring, the zero impulse to the print magnet is completed to the fuse side regardless of significant figures. The circuit is as follows: (Use print magnet position 2 as an example.) The zero impulse is directed into the print entry hub 2, through the 15-2n/c points, the print contact 2, R125-2n/o, and the zero print control hub 2, to the zero print entry, which is connected through a cam (at zero time) to the fuse side of the line.

It should be noted that the circuit did not go through any n/o point of zero print contacts, meaning that significant figures are not necessary, in the above case, to print zeros.

5.5.00 SPECIAL CHARACTER PRINTING

Decimal Printing

To indicate decimal figures, a decimal may automatically be printed before or between groups of numbers such as 153.25, .42, .05, or .007. If the method of wiring the control panel is such that a zero total will not print zeros, the decimal will not print even though it is wired to print. However, if the control panel is wired to print zeros when the total is zero, the decimal will precede the zeros even though no significant figures appear. For example, .00 may be printed or left entirely blank depending upon the manner in which the control panel is wired.

The impulse to print the decimal is obtained from the decimal hubs, which are exit hubs. These hubs emit two impulses, one at 12 time and the other at 335^{o}. The 335^{o} impulse has the effect of an 8-3 combination on the print unit, except that the zero print contacts are not transferred by this impulse as they would be for a normal 8-3 impulse. Mechanical operation prevents their transferring. By not transferring the zero print contact, the decimal can be prevented from printing unless a significant figure appears in the field.

To print the decimal, the decimal hub is wired to the print entry hub corresponding to the type wheel in which the decimal is desired. The print entry hub used depends on the type of operation being performed. Also, the zero print control lower hub corresponding to the position in which the decimal is to print must be wired to the zero print control upper hub of the position immediately to the right of the units position, as was done in the preceding section when printing zeros. Also, all zero print control hubs for all positions of the group except the highest order position of the group must be wired together.

The 335^{o} impulse is received right after the print cam has unlatched all analyzer pawls. As can be seen by the mechanical timing chart, analyzer pawls 3 and 8 are latched up when the print magnet becomes energized at 335^{o}. However, the zero print contact is not transferred because the zero print contact cam keeps the contacts latched at this time.

The circuit to the print magnet at this time is as follows: from the decimal hub (13B), through the control panel wire to the print entry hub (11-12A), n/c point of the N relay, the print magnet, the n/c print contact points, and the n/c OXRN point to the fuse. As mentioned above, this causes analyzer pawls 3 and 8 to be latched, but the zero print contact is not transferred. Because the zero print contact is not transferred, the 12 impulse is not completed to the print magnet through its n/o print contact points, but depends on an adjacent position to have its zero print contact transferred.

When the decimal hub emits an impulse at 12 time, the following circuit is completed to the print magnet, provided at least one zero print contact is transferred: through the control panel wire, the print entry hub, n/c N relay points, the print magnet, the n/c zero print contact, the n/o OXRN relay point, the lower hub of the zero print controls hubs, the control panel wire, the zero print control upper hub of the position

immediately to the right of the units position of this field, the n/o point of the OXRC relay, and n/o zero print contact, to the fuse. Energizing the print magnet at this time causes the print cam to operate. The selector clutch gear has previously started operating at 135^{o}, since an 8-3 test was made at 119^{o}.

Under normal wiring conditions, if no significant figure has been set up to print, none of the zero print contacts will be transferred. This means that the circuit for the decimal is not completed because the circuit depends upon some zero print contact being transferred within the group concerned.

The difference between wiring when printing zeros, for a zero total alone with the decimal, and not printing either, lies with the zero print control wiring. The hubs corresponding to the position immediately to the right of the decimal should be wired to the zero entry hubs to cause zeros and the decimal to print on zero totals. The remaining wiring stays the same as in the preceding condition.

Decimal Hub of the Character Emitter (13A)

The decimal hubs of the character emitter, when wired to the print entry hubs, cause decimals to be printed, regardless of figures to the left or right, because the zero print contact is transferred by the first impulse emitted by the hub, which is an 8 impulse. The circuits are the same as for any normal printing operation except that three impulses are received from the hub instead of the usual one or two.

Comma Printing

A comma may be used to great advantage in separating thousands, millions, and so on, to facilitate reading the figures. The comma may be printed in any type wheel desired and may be controlled to print only when a significant number appears to the left. This prevents commas from being printed by themselves when no figures are being separated.

Comma printing is similar to that for the decimal. The comma hub (13B) emits two impulses as does the decimal hub. The main difference in the two hubs is that the comma hub emits its second impulse at zero time, whereas, the decimal hub emits its second impulse at 12 time. The first impulse, at 335^{o}, is the same for both hubs.

The control panel wiring is the same as it would be for normal zero printing control with provisions made for a comma to print in every fourth type position, assuming no decimal position. Each fourth type position should have the zero print control hubs wired also, as though zeros were to print in those positions. This wiring allows the zeros to be carried to the next group to the right and permits printing of a comma if a digit is to the left. The print entry hub for the type position into which the commas are to print is wired from the comma hub.

The first impulse from the comma hub is emitted at 335^{o} and causes the analyzer pawls 8 and 3 to be latched, which at 135^{o} causes the selector clutch gear to start revolving. The second impulse comes at 140^{o}, which corresponds to zero time. This causes the print cam to start revolving at 153^{o}, and a comma is printed. The print magnet circuit at 335^{o} is identical to the circuit at 335^{o} time when printing decimals. As before, the zero print contacts do not transfer as a result of the print magnet being energized at this time.

The second impulse from the comma hubs causes the print cam to start operating at 153°. The selector clutch gear previously started moving at 135°. The combination of the two causes a comma to be printed. The circuit is as follows: from the comma hub (13B), through the control panel wire to the print entry hub (11A), the n/c N relay point, the print magnet, the n/c zero print contact, the n/o OXRN relay point, the jackplugged zero control hubs, the OXRC n/o point, and the n/o zero print contact point, to the fuse. Note that there must be at least one zero print contact to the left of the comma printing position that is transferred in order to print a comma.

Comma Hubs of the Character Emitter (13B)

The comma hubs of the character emitter, when wired to the print wheels, cause commas to print regardless of figures to the left, since the zero print contact is transferred by the first impulse. The 8-3 impulses come through at the normal 8-3 time when using the comma hub of the emitter. The circuits are the same as for any normal printing operation with the exception that three impulses are received from the hub instead of one or two.

Dollar Sign Printing

There are two different dollar sign ($) hubs on the control panel. One is part of the character emitter and the other is a special symbol ($) hub. The character emitter is used when the dollar sign is desired on every cycle. The special symbol hub is used when the dollar sign is desired only if a significant figure prints in the field where the dollar sign is used. The dollar sign may be printed in any type wheel desired, provided at least one significant figure is contained in the amount to be printed.

The zero print control hubs are wired in a manner similar to that for printing a decimal, but with the dollar sign usually taking a different relative position. All zero print control hubs, except the highest order position, are jackplugged for the amount field. The zero print control lower hub corresponding to the position in which the dollar sign is to be printed should be wired to the zero print control upper hub of the position immediately to the right of the units printing position. The $ hub (13B) is wired to the print entry hub corresponding to the desired type position.

The circuit to the print magnet is the same as that for printing the decimal with the exception that the second impulse from the dollar sign hub is emitted at 11 time, whereas the impulse from the decimal hub is emitted at 12 time. These two symbols are next to each other on the print wheel. The difference in the timing of the second impulse accounts for the different symbols printing.

As in the case of the decimal, the analyzer pawls 8 and 3 are latched without the zero print contact being transferred. This makes it possible to control dollar sign printing with the zero print control wiring. If the contact is to transfer while the analyzer pawls 8 and 3 are latched, zero print control over the dollar sign would be lost.

The circuit to print the dollar sign, provided at least one significant figure appears in the amount, originates from the dollar sign symbol hub. The circuit is from the dollar sign hub (13B), through the control panel wire to the print entry hubs (11A), through the n/c N relay point, the print magnet, the n/c zero print contact, and the OXRN n/c point, to the fuse. This first impulse energizes the print magnet at 335° and causes the analyzer pawls 3 and 8 to be latched. However, the zero print contact for the

corresponding print magnet is not transferred at this time because of the position of the zero print contact cam. Therefore, the impulse to the same print magnet at 11 time is not completed through the n/o points of its zero print contact as most second impulses are, but must be completed through the n/o point of some other print magnet position. This arrangement prevents the dollar sign from printing unless a significant figure is printed in the amount involved.

With the analyzer slides 3 and 8 latched, the selector clutch gear starts revolving at 135^{o} so that at printing time the dollar sign will be properly positioned for printing. The impulse causing the print cam to operate comes through from the same $ hubs from 155^{o} to 167^{o} but must pass through a n/o point of a zero print contact. Assuming that the second type wheel is set up to print a significant figure, the circuit to magnet 1 to cause a dollar sign to print is as follows: from the $ hub, through the control panel wire, the print entry hub, the n/c N relay point, the print magnet, the n/c zero print contact, the n/o OXRN point, the lower hub of the zero print control hubs, control panel wire, the upper hub of zero print control hubs, control panel wire, the upper hub of zero print control hub for the position immediately to the right of the units position in the group concerned, the n/o OXRC point, and n/o side of the units position zero print contact, to the fuse. This causes the print cam clutch to become engaged at 11 time, and, since the selector clutch had previously engaged, the dollar sign is printed.

Dollar Sign from the Character Emitter (13A)

When the $ hub of the character emitter is wired to the print wheel, the dollar sign prints, regardless of any significant figures present. The circuit is the same as any normal printing circuit that has more than one impulse other than the automatic N impulse.

Asterisk Printing

There are two asterisk hubs on the control panel, an asterisk exit hub which emits 8-4-11 impulses, and an asterisk entry hub which accepts N impulses. The asterisk exit hub is used to identify a total or a print cycle.

The first two impulses set up the analyzer unit and cause the selector clutch gear to operate, which in turn rotates the type wheel. The third, 11, impulse causes the print cam to operate so that an * is printed.

The printing of an asterisk to fill in the field preceding an amount creates a different situation because of the undetermined number of positions needed each time. The above method cannot be used since there is no way of knowing in advance just how many digits in the field are to be used for numbers. A separate asterisk is positioned on the print wheel, which is located in such a position that all numbers take precedence over the asterisk. An N impulse by itself causes the asterisk to print. In this way the machine may print a number in any position of the amount field. If the type wheel is not conditioned to print a significant figure (9 through 1), the asterisk may be printed instead of leaving it blank or printing zeros. There are two methods for printing these asterisks. One method causes asterisks to print to the left of significant figures or to print in all positions in case of no amount. The other method causes asterisks to print to the left of significant figures only if at least one significant figure appears in the amount. A zero balance is left blank.

Asterisk (*) Printing to the Left of Significant Figures and for Zero Total

Because the first method is more common, it will be covered first. The zeros must still be printed to the right of significant figures, which means that provisions must be made for normal wiring of the zero print control hubs for zero printing, as well as provisions for the printing of asterisks. A co-selector is used to provide both conditions. The control panel is wired as follows: the lower row of zero print control hubs should be wired to the common hubs of one or more co-selectors.. The upper row of zero print control hubs should be wired to the normal hubs of the same co-selector. As long as the co-selector is not energized at zero time, this wiring causes zeros to print to the right of significant figures. The transfer hubs of the same co-selector should be commoned together, either by split wires or bus hubs. These commoned transfer hubs should, in turn, be wired to the asterisk (*) entry hub (12A). This wiring connects the lower hub of the zero print control hubs to the asterisk entry hub when the selector is energized. The co-selector shold be energized at N time, which is the time the asterisk entry hubs are affected. The co-selector should be picked up by the asterisk control hub (4A). This hub causes the selector to be energized only after N time.

The circuit through the normal points of the co-selector causes zeros to print to the right of significant figures in the usual manner as follows: (Assume that type wheel 60 is set up for the significant figure.) Type wheel 61 should print a zero. The circuit is as follows: the zero impulse from the system comes through a control panel wire to the print entry hub for type position 61, through the n/c N relay point, print magnet 61, n/c side of zero print contact, n/o OXRN relay point, lower hub of the zero print control hubs, control panel wire, the normal points of the co-selector, control panel wire, upper hub of zero print control hubs, n/o points of OXRC relay and the zero print contact 60 n/o point, to the fuse.

The circuit to print the asterisk is completed at N time through the transferred points of the co-selector. Assuming that print magnet 61 has a significant figure set up, print magnet 60 and those to the left should print an asterisk. The circuit for the asterisk in position 60 is as follows: through print magnet 60, zero print contact n/c point, OXRN relay n/o point, zero print control lower hub, control panel wire, common hub of co-selector, transfer points of co-selector (which is common to all other transfer points), the control panel wire, the asterisk entry hub, and through CR36, to the fuse. All positions to the left have parallel circuits to the above at N time. Energizing the print magnets at N time, if they have not previously been energized, causes an asterisk to print. It should be noted that the circuit for this (*) printing does not go through any n/o points of the zero print contacts. Therefore, no significant number is necessary to print the asterisk under these conditions. If the amount is zero, the entire field will be printed with asterisks.

Asterisk (*) Printing to the Left of a Significant Figure but not for Zero Total

The method of printing an asterisk to the left but leaving the field blank if the amount is zero is covered in the next paragraphs.

The entry hubs are not used in this case, and a transferred zero print contact is necessary. A co-selector is needed to provide normal wiring of the zero print control hubs for printing zeros to the right of significant numbers as in a normal operation, and also to print the necessary asterisks. The control panel should be wired as follows: the lower hubs of the zero print control hubs should be wired to the common hubs of one

or more co-selectors; the upper row of zero print control hubs should be wired to the normal hubs of the same co-selector; the transfer hubs of the same selectors should be commoned together; the co-selector should be picked up by the asterisk control hub. This hub causes the selector to be energized only at N time (the time for printing an asterisk).

The circuit through the normal points of the co-selector causes zeros to print to the right of significant figures in the usual manner. Assume that type wheel 60 is to print a significant figure; then type wheel 61 should print a zero. The circuit is as follows: the zero impulse from the system comes through a control panel wire to the print entry hub for type position 61, n/o N relay point, print magnet, n/c zero print contact, the n/o OXRN relay point, the lower hub of the zero print control hubs, control panel wire, normal points of the co-selector, control panel wire, upper hub of zero print control, n/o OXRC point, and the zero print contact 60 n/o, to the fuse. The circuit to print the asterisk comes through at N time, through the transferred points of the co-selector. Assuming that print magnet 61 has a significant figure set up, print magnet 60 and those to the left should have an asterisk (*). The circuit is through a n/c N relay point, print magnet 60, through the n/c side of the zero print contact, the n/o OXRN point, the zero print control lower hub, the control panel wire, common hub of co-selector, transfer points of co-selector, transfer hub of co-selector (which is common to all other transferred positions at this time), lower hubs of the zero print control hubs, back through transfer points of co-selector for the position that has a significant figure set up (zero print contact transferred, in this case position 61), lower hub of zero print control hub for positions 61, the n/c OXRC relay point, and zero print contact 61 n/o, to a fuse.

This causes the print magnet 60 to be energized at N time and as asterisk (*) prints in type wheel 60. All positions to the left that are wired to the co-selector receive impulses at the same time that all lower hubs of the zero print control hubs for the positions involved are commoned together. Note that the circuit goes through the normally open zero print contact. At least one of the zero print contacts in the field involved must be transferred to complete the above circuits to print the asterisk. Lack of at least one zero print contact being transferred indicates a zero total and no asterisks are printed. This lone impulse, effective at N time, causes the print cam to start revolving at 198^{o} and the selector clutch gear to start revolving at 300^{o}. This combination causes the asterisk (*) to print.

Minus (-) and Plus (+)

The minus and plus hubs may be used to print minus (-) or plus (+) to the left of a group of letters or figures. The impulse to cause minus (-) to print comes through at 11 time. The impulse to cause plus (+) to print comes through at 12 time. The 11 or 12 impulse may be obtained from the system or the character emitter. The impulse must be wired to the print entry hubs for the type wheel position in which the minus (-) or plus (+) printing is desired. The zero print control hubs must be wired with the lower hub connected to the (-) or (+) hubs. In this manner the circuit does not depend on the zero print contacts being transferred. The circuits are the same as those for printing zeros to the left when using the zero entry hubs, except for the difference in the time the circuit is completed.

Other Special Characters

The print wheel has a total of 9 different special type faces, as can be seen on the type wheel (Figure 12-1). There are two asterisk symbols, two plus symbols, and two

minus symbols. The preceding sections describe the particular operations and circuits of some of the important symbols included in the above special characters. The special characters other than those previously mentioned may be printed by using the character emitter in conjunction with pilot or co-selectors. The impulses from the character emitter will, in most cases, be directed to the print entry hubs directly or through co-selectors, depending upon the conditions under which the printing is desired.

Character Emitter

The 716 is equipped with a character emitter from which any one of the 48 characters may be printed. Included in the character emitter are all of the special characters. The character emitter hubs are under the control of the OXRC relays and the 8 relays.

OXRC Relays

The OXRC relays are used to allow more than one impulse to be emitted from the letter hubs and from some special character hubs of the character emitter, and still prevent the shorting of the various impulses at other times.

The 8 Relays

R53 energizes from 15^{o} to 30^{o}, which overlaps the normal time for sensing an eight impulse; thus, the reason for the name of the relay. As mentioned previously, special characters are obtained by a 3 or 4 and 8 impulse, with or without a zone punch. The purpose of relay 53 is to allow the special character hubs of the character emitter to emit an 8 impulse from the same hub that emits 3, 4 and/or zone impulses, and still not cause these various impulses to be shorted together at other times.

The circuits to the character emitter hubs originate from the read impulse distributor. When the CR cam makes at 8 time, an impulse is emitted from the 8, Y, Q, H, (,), $, +, -, (.), ¤ , *, and % hubs of the character emitter. All of the above hubs, with the exception of the 8 hub, will emit one or more other impulses.

5.6.00 TRANSFER OF INFORMATION AND DISCONNECT

Writing With the Printer

The printing mechanism employed in the 716 printer was originally designed to print from decimal counters or decimal coded punched cards. The present application of the printing mechanism requires that the external system organize the material to be printed to form a card image. The card image is transmitted a row at a time during set up times for the print positions.

The transmission from the system to the print magnets is from the calculator exit hubs, to the print entry hubs, at the printer control panel. The time at which transmission may occur is determined by the master CB and CF cam timing.

A CB set pulse is employed to indicate to the system that the print magnets are ready for impulsing. Such a CB set must be generated prior to set up time for 9 through 12 rows. The circuit for the CB set is through the master CB's (Systems 15A), CR50, CR51, and CR44 (Systems 16A), CR43, and R447AL. After indicating to the system that set up time has occurred, the master CB's are also used to provide gating of data to the calculator exits.

There are two sets of calculator exit hubs. Because of control with the external system, a fraction of a millisecond delay occurs between activating the calculator exit left and the calculator exit right hubs. This delay is too slight to have any bearing on set up of the print magnets. At the completion of transmission of a row, a CB reset indicates to the system that set up is not possible until another CB set has occurred. The CB reset circuit is through CR48 (Systems 15B), CR49 and R439-1.

Writing and Reading the Printer

Through use of the type wheel contacts of the 716 print mechanism, it is possible for a system to compare the printed output with the data originally required to print. A printer read select instruction is employed by the system if checking is to be done. At the printer control panel the print echo exit hubs are wired to the calculator echo entry hubs.

When a printer read select instruction is given, the digit impulses (9 through 1) that are received during write impulse time are made available at the print echo exit hubs (Systems 12A). These impulses appear in the same sequence as they were received, but 150^{o} later in the machine cycle. The special symbol combination pulses (8-4, 8-3) are made available at the print echo exit hubs (Systems 12A) during the 9 and 10 CB times, respectively.

The four degree echo pulses are available at the common point of the type wheel contacts through CR67, CR68 (Systems 16A), CF8, and CF9 (Systems 11A).

The type wheel contacts close when the selector gear is set in motion. This occurs 150^{o} after a 9 through 1 impulse is received by the print magnets, and at 120^{o} and 135^{o} for 8-4 and 8-3 pulses, respectively.

The digit echo impulses may be read back to the system and checked against the original information in core storage to see that the correct information printed. The 8-4 and 8-3 impulses indicate the sign of the figure printed. They are read back to check the original sign.

It should be noted that the printer must read and write during the 9 through 12 CB times. It is necessary during this time that the system provide data at the calculator exit hubs and also accomodate the data at the calculator entry hubs. Through system programming the necessary comparisons of data and echo information must be accomplished to complete the checking of printing.

Because of system restrictions only 72 print positions may be checked. Remember that a maximum of 72 positions may be printed under system control. Additional positions may be printed with split wiring, but no means exist for checking more than the 72 positions wired to calculator entry hubs.

Printer Disconnect

A disconnect signal is generated in the external system to indicate to the printer that no further transmission of data is to be done at that time. The disconnect signal energizes R440 (Systems 15B). The points of R440 opens the hold circuits to R446 and R447, the printing isolation and type wheel contact isolation relays (Systems 5A). R440 holds through CF36 until 285^{o} of the print cycle (Systems 5B).

The isolation control relays do not drop immediately after the R440 points open. The relays are held through CR60 or CR63 until 2^{o} before the end of the cycle (Systems 5B).

After 447BU breaks, R439, the write trigger reset control relay, is still held through CR64 or CR65 until 3^{o} after the cycle point time. After 446BU breaks, R438, the read trigger reset control, is held through CR64 or CR65 until 3^{o} after the cycle point time. These added holds insure that all information is transferred.

5.7.00 SELECTORS AND SPLIT COLUMN CONTROL

Pilot Selectors (Systems 10)

A pilot selector is a relay equipped with two transfer points that are directly connected to the control panel and act as an automatic switch. Each point is so wired that the operating point is connected to the C (common) hub of the control panel. The n/c point is connected to the N (normal) hub and the n/o point is connected to the T (transferred) hub of the control panel.

With the pilot selector relay normal, a circuit can be completed through the C and N hubs of the control panel; a circuit can be completed through the C and T hubs when the pilot selector relay is energized.

The energization of each pilot selector relay can be independently controlled by impulsing the pickup hubs located on the control panel for each pilot selector position.

The pickup hub of the pilot selector is receptive at all times. An impulse into the pickup hub anytime after 5^{o} of a print cycle and before 320^{o} causes the pilot selector points to transfer for the next print cycle.

The pilot selector points may be used to control special character printing, skipping, or pickup of other selectors.

The pilot selector coupling exit (Systems 10B) of the pilot selector emits an impulse from 330^{o} to 195^{o} of the cycles that the pilot selector relay points are held transferred.

The pilot selector coupling exit impulse can be used to pick co-selectors for controlling special character or zero printing, or conditional transfer of information.

Co-Selectors (Systems 9B)

Co-Selectors are so named because these are often used in conjunction with pilot selectors. Each selector has five positions, each position having a C, N, and T hub.

The co-selector can be picked up any time after 350^{o} of a print cycle. The points are held transferred until 285^{o} of the same print cycle.

The co-selectors can be used to control special character or zero printing, or conditional transfer of information.

Split Column Control (Systems 9B)

Split column control is an emitter that provides timed impulses that occur between the normal 9 through 11 impulses. For example, the 9 hub of the split column control emits an impulse (14^{O} to 22^{O}) which is between the normal 9 (6^{O}-15^{O}) and 8 (21^{O}-30^{O}) impulses.

6.0.00 IBM 922 TAPE-CONTROLLED CARRIAGE

6.1.00 FUNCTIONAL PRINCIPLES

The tape-controlled carriage controls the feeding and spacing of forms while data is being transcribed by the printer. The carriage is controlled by punched holes in a paper tape. Holes punched in the tape stop the form when it reaches any predetermined position. One of the punched holes in the tape can be used to control the printer to start overflow skipping to the next form.

The carriage accommodates continuous forms measured in sixths of an inch up to a maximum of 22 inches in length and 16-3/4 inches in width, including punched margins. Forms can be designed to permit printing in practically any desired arrangement. Skipping can be controlled to ten different sections of the form.

The mechanical principles and operating controls are unchanged in 716 application from 407 applications. For this reason only the carriage circuits are covered in this section.

6.2.00 MAJOR CIRCUITS

The carriage circuits are energized from the 46v generator supply. The carriage motor (Systems 8A) operates as long as the printer main line switch is on.

The speed of the carriage is in terms of the rpm of the carriage tape contact roll. The carriage motor control resistor (Systems 8A) should be adjusted to obtain a minimum speed of the carriage tape contact roll of 140 rpm with the high speed clutch engaged. This results in approximately 64 rpm of the carriage tape contact roll with the slow speed clutch engaged.

The high speed clutch is engaged for all skip-to operations and for restoring. Slow speed is used for all spacing and overflow operations. It is important that the motor speed be maintained in order to insure a full 12 space (2 inch) ejection without interlocking.

The slow speed chart (Figure 6.2-1) is drawn to a millisecond scale, and the degree of 716 time is based on the normal 716 speed of 150 rpm.

The normal spacing operation is started by the closing of CR21 at 120° (Systems 7A). At 127° the points of 461 BU have transferred (Systems 8A). At 133° the armature of the clutch magnet starts toward the core. This lifts the detent out of the detent wheel and operates the low speed interposer. A few milliseconds later, the platen begins to turn. At the same time the carriage CB begins to turn (Systems 7A). At the time the CB closes, the detent latch overlaps the tooth of the detent wheel approximately one third on the leading edge. The closing of the carriage CB

starts the carriage stopping operation. When the CB opens, the detent latch overlaps the detent tooth approximately one third on the trailing edge. The armature is pulled away from the cores of the clutch magnet. Because the detent latch rests on a tooth of the detent wheel, the T lever does not permit the clutch to disengage. Therefore, the carriage CB points are open when the detent latch is seated in the detent wheel.

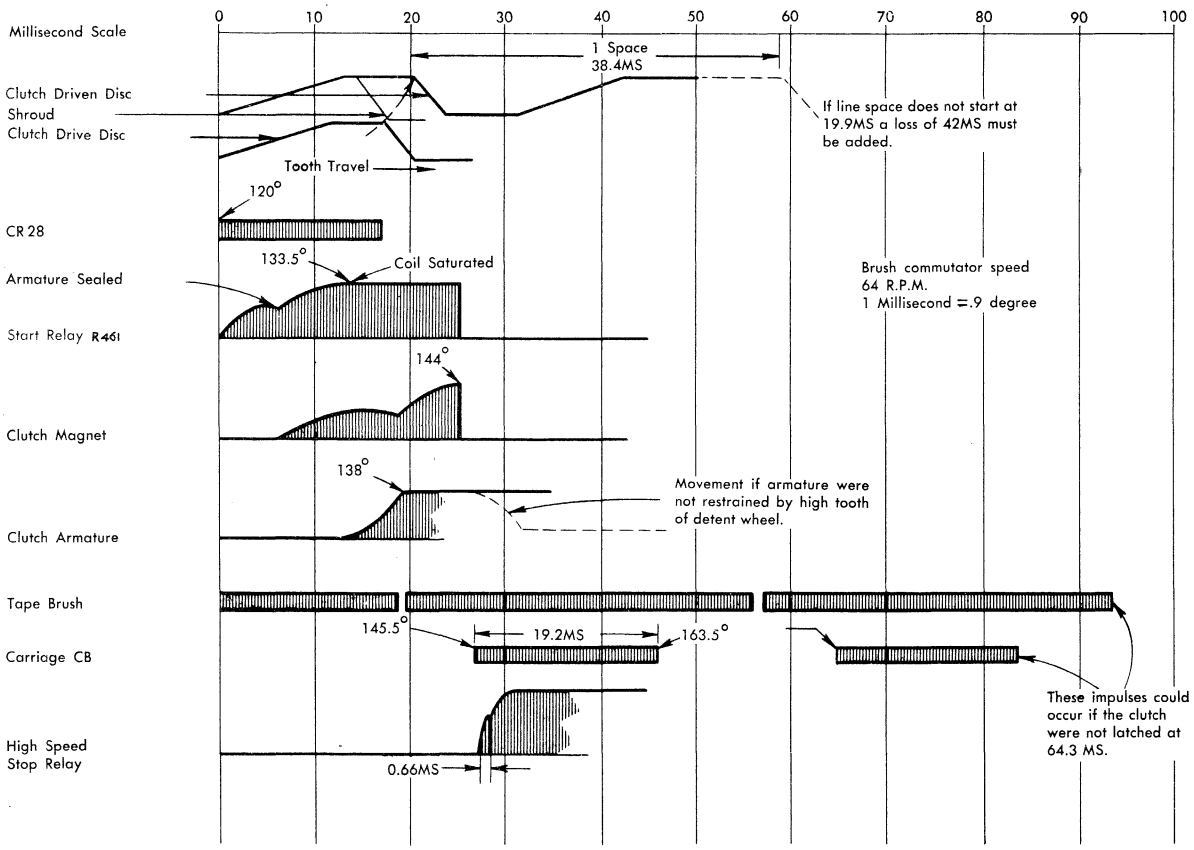


FIGURE 6.2-1. 922 SLOW SPEED CARRIAGE OPERATION RELATIVE TIMING

By 150° the detent rests on the high part of the detent wheel. As the detent falls into a tooth of the detent wheel, the clutch engaging arm releases the driven disk from the drive disk. The paper has spaced 1/6 inch upward.

The timings given above are approximate and, under some conditions, the actual operation might take 42 milliseconds longer than is indicated.

6.3.00 MANUAL CONTROLS AND CIRCUITS

Space Switch (Systems 8A)

Depressing this switch causes one space operation, regardless of how long it is held depressed, according to the space control hub wiring. It is necessary that one set of space control hubs be jackplugged when a control panel is in position.

Depressing the space switch energizes the PL coil of R461, the carriage start relay (Systems 8A); R461 BU transfers, and the clutch magnet becomes energized. The R461 AL points close to hold R461H and pick RR463. R463 AL opens the pick to R461, and R463 AU and the space switch hold R463. This prevents repicking R461 after the first space, while the space switch is held depressed.

As soon as the clutch magnet armature is attracted and the detent latch clears the detent wheel, the low-speed clutch will cause the drive mechanism to advance. The cam shaft drive gear turns and with it the carriage circuit breaker. When the carriage CB makes, or after finding an 11 hole in the tape, the high-speed stop relay, R467 (Systems 8B), is energized through R461 AU and a space control jackplug.

R467 opens the R461 hold circuit, and spacing stops after the first space operation (single, double, or selective space).

The high-speed relay is designed to pick in less than one millisecond and, because the circuit breaker closes very soon after the space starts, the clutch magnet circuit is broken early in the operation. The detent latch is under spring tension; this forces the latch into the detent wheel and breaks any residual magnetism at the armature.

Stop Switch (Systems 8B)

Depressing the carriage stop switch causes both the 922 carriage and the 716 to stop operation.

Depressing the stop switch energizes R344; R344-2 (Systems 8B) and R344-4 (Systems 7B) stop spacing or skipping that might have been started for any reason. R344-1 (Systems 3B) opens the calculator interlock relay hold circuit to stop the printer and turn off the ready light.

Restore Switch (Systems 8A)

Depressing this switch causes the carriage to restore to the hole punched in channel 1 of the tape. The carriage brushes must be down on the contact roll whether or not there is a tape on the roll. Otherwise, spacing continues until the stop switch is depressed.

Restoring takes place at high speed, and the position of the platen clutch knob determines if the platen will advance at the same time with the control tape.

The carriage restore switch picks R462. R462 AL closes to pick R461 BU. This starts the spacing. R462 BU (Systems 7B) connects the high-speed stop relay, R467, to brush 1. When the channel 1 brush finds the hole in tape channel 1, the restore operation stops.

R462 is held to the line through R461 AL until the restore operation stops. If the restore switch is held depressed, only one restore operation takes place because the high-speed stop relays are held energized through R461 AUn/o, R459 ALn/c, R468 An/o, and R464 Bn/c.

6.4.00 CARRIAGE CONTROL RELAYS

Common Space Control R454 (Systems 7A)

In order to space or skip in any manner except through the use of the carriage control switches, it is necessary to energize the common space control relay. The R454 AU points assure that the platen lock magnet will not be energized when the 716 is stopped. The R454 B points assure that the carriage will not space while the 716 is stopped.

All Skips R458 and R459 (Systems 6A)

These relays are normally energized and their pick circuit is broken only on a carriage skip. They serve certain interlocking functions that will become apparent in the following circuit descriptions.

Space or Skip Control After R455 (Systems 6B)

The pick circuit to this relay can be completed only after printing has taken place. Extra spacing and skipping can take place only after printing because these operations are started by impulses directed through R455n/o points.

First Line Suppression R460 (Systems 6B)

This relay prevents spacing before printing the first line after turning on the printer or after a skip, overflow, or restore operation.

Skip End Control R464 (Systems 8A)

This relay becomes energized after each operation of the carriage. The 464 A points assure that the platen lock magnet (Systems 8A) cannot be energized during a carriage operation. R464 B (Systems 8B) opens the hold circuit to the double space and skip end relays.

Skip Interlock R341 (Systems 8B)

This relay is up from 230° to 315° of each cycle. Its points condition the input hubs to the skip control relays. These skip control relays can be energized only while R341 is energized.

6.5.00 NORMAL LINE SPACING AND SELECTIVE SPACING BEFORE PRINTING

Single, double, and selective spacing before printing is carried out by jackplugging the proper space control hubs and, in the case of selective spacing, punching the paper tape for the spacing desired.

The space before printing operation is started by a CR impulse and stopped by directing a carriage CB through the jackplugged space control hubs to the high-speed stop relays.

The circuit is as follows: assume first that the space control 1 hubs (Systems 7B) are jackplugged and that the first line has been printed after skipping, restoring, or just starting the machine. The circuit to the start magnet is through CR21 at 120° (Systems 7A), R460 BUn/o, R452 BUn/c, R456 ALn/c, R454 Bn/o, and R455 B, to R461 PL.

When R461 BU (Systems 8A) transfers, a circuit is completed to the clutch magnet through R458 BLn/o, causing the low-speed clutch to engage and raising the detent from the detent wheel. R461 holds to L7 until R467 is energized.

The carriage CB (Systems 7A) closes just after the platen starts to turn. A circuit is then completed from L8, through the carriage CB, the space control 1 hubs, R346-2n/c, the n/c carriage skip relay points, R462 BU, and R461 AUn/o, to R467.

R467 A (Systems 8B) opens the R461 hold circuit, and R461BU (Systems 8A) opens the clutch magnet circuit. When R461 BU drops, R464 becomes energized. The magnet is de-energized before the detent wheel moves one pitch distance. The clutch becomes disengaged when the detent latch drops into a tooth of the detent wheel to hold the platen. The form has spaced upward 1/6 inch.

Had the space control 2 hubs (Systems 7B) been wired, the spacing operation would have taken place in the following manner. After starting the spacing operation in the normal way, the first carriage CB impulse energizes R345, through R346-3n/c (Systems 8B). R345 holds through R345-1n/o and the carriage CB. When R345-3 closes, R346 is energized through R464 Bn/c and R345-3n/o. R346 holds through R346-1n/o and R464 Bn/c. The circuit to the high-speed stop relay, R467, is not closed; therefore, the clutch magnet remains energized and the platen continues to turn.

When the carriage CB breaks, R345 drops. When the carriage CB makes at the start of the second space, a circuit is complete to the stop number 1 relays, through R345-1n/c, R346-2n/o, the skip relay points, R462 BUn/c and R461 AUn/o.

The space operation is then stopped in the manner described above, but two lines have been spaced; that is, the clutch magnet has been energized long enough to turn the platen through 1/3 inch.

When irregular spacing is required, the selective space control hubs are used, and the 11 channel of the tape is punched as required. The space operation is started in the manner described above, and continues until an 11 channel punch is sensed by the carriage brush.

When the selective space hubs (Systems 7B) are wired, R346 (Systems 8B) picks at the start of each spacing or skipping operation; that is, when R464 drops. Once spacing is started, it continues until an 11 channel hole is sensed. At that time an impulse is directed through the carriage CB, common brush, 11 channel hole, 11 brush, R346-4n/o, R345-2n/c, R346-2n/o, skip relay points, R462 BUn/c and R461 AUn/o to the stop relays.

6.6.00 SPACING AFTER PRINTING AND SPACE SUPPRESSION

An extra single, double, or selective space operation may be obtained by pulsing the extra space hub any time after 5°. An impulse picks R457, which holds through its A point and CR 12 until 330° of the current cycle. The space or skip control after relay, R455, (Systems 6B), becomes energized at 280° through CR 14 and R457 Bn/o. R455 holds through R455 AU and CR19. When CR22 (Systems 7A) makes at 338°, a circuit is completed through R455 Bn/o to the carriage start relay. The carriage is stopped in the same manner described above.

Space Suppression

Spacing before printing can be suppressed by impulsing the space suppress hubs (Systems 6B) before 110°. The space suppression relay, R456, is held through its AU n/o point and CR17 until 140°. This opens the normal space start circuit until after CR21 opens at 135°.

For single, double or triple line spacing, it is normal to start carriage spacing operations before printing. However, if the distance to be spaced exceeds three line spaces, there is not sufficient time to complete the spacing operation before printing. Therefore, it is necessary to change to an after printing spacing operation, which provides maximum time between the start of the spacing operation and printing time. This is done by wiring print cycles to both extra space and space suppress.

Wiring the space suppress hub only would suppress all normal spacing. Wiring the extra space hub causes spacing after printing.

Since spacing is a carriage slow-speed operation six line spaces is the maximum distance that can be spaced after printing without interlocking the 716 and still maintain a safety factor. There is no provision made to interlock the machine and the carriage during a spacing operation.

6.7.00 FORM-TO-FORM EJECTION

When continuous forms are being used, the normal procedure is to leave a margin at the top and bottom of the form. A simple overflow operation causes the carriage to move to the next form when the form has reached a predetermined position. Three points must be determined ahead of time: (1) the length of the sheet, (2) the position of the first printing line, and (3) the position of the last printing line.

The tape length must be the length of the form or an equal multiple of the length of the form. The first punch in the tape must be punched in channel 1, in a position corresponding to the position for printing the first line. Channel 12 must be punched in the position corresponding to the last line to be printed.

The overflow hubs should be wired to the carriage skip 1 hub if the overflow is to be controlled only by the 716 circuits, or to the sense entry hub, if the overflow is to be controlled by a sense instruction.

Until the hole is read in channel 12 of the tape, the carriage spaces in the normal manner. As the 12 channel hole is read, a circuit is completed through the carriage CB (Systems 7A), common brush, 12 channel hole, 12 brush, and R459 BU to the overflow relay, R465. R465 holds to L6 through R465AUn/o and R469 An/c or R348-2n/o. R465 ALn/o closes at this time and the overflow hub is connected to line 7.

Assume now that the overflow hub is plug-wired to carriage skip 1 hub. When R341-1n/o closes at 230°, R431 is energized (Systems 6A). R331 is held through R331-1n/o and R348-2n/o or R469 An/c and to L6. This opens the pick circuit to the all skips relays, R458 and R459, and the hold circuit to the first line suppression relay, R460 (Systems 6B). R331-3n/c (Systems 3A) opens the pick to the auto start relay, R388, unless the short skip relays are energized. These relays are held through CF20 until 320°. R331-4 opens the pick to R348. R348 becomes de-energized at 348°. When R458 BUn/c (Systems 6B) closes at 320°, R455, the space or skip control after relay, is energized. R455 holds through CR19 until 10° of the next cycle. When CR22 closes at 338° (Systems 7A), the skipping operation is started.

Because R458 is normal at this time, a circuit is completed to the high-speed interposer magnet through 458 BLn/c and 461 BUn/o to L10. When the high-speed interposer magnet armature is attracted, the IM contact closes and energizes the clutch magnet, causing the carriage to overflow at high speed.

Since the normal space stop circuit is opened when R331-2 transfers, the carriage continues to move the form until a new stop circuit is completed. The stop relays become energized when the 1 channel hole is sensed, through R331-2n/o (Systems 7B), R462 BUn/c and R461 AUn/o.

At the same time that the stop number 1 relays are energized, the high speed relays, R468 and R469, are energized (Systems 8B). These relays hold through R468 An/o and R464 Bn/c until the carriage start relay is de-energized. R469 A (Systems 6A) opens the hold for R465, the overflow relay, and R331, the skip control relay.

The carriage is now stopped with the first line in printing position.

The carriage is prevented from spacing before the first line is printed because the first line space suppression relay, R460 (Systems 6B), does not become energized until 215° of the first printing cycle. Relays 458 and 459 become energized after the skip is completed, to restore the spacing circuits to normal.

After R331-3 closes, the auto start relay, R388 (Systems 3A), is again energized when CR28 makes.

The overflow operation may be controlled from the system by wiring the overflow hub to sense entry. This requires that a sense exit be wired to the carriage skip 1 hub.

When the overflow distance is less than two inches, the start circuit interlock may be suppressed to permit continuous operation. This is done by wiring overflow to short skip.

6.8.00 CONTROLLED SKIPPING AND INTERLOCK RELEASE

Skipping is controlled by directing impulses to the various carriage-skip hubs. These pulses usually originate from sense exit or overflow hubs.

The skipping control circuits are similar to the circuits described above for the overflow operation. The only difference is that a skip is usually initiated from a sense exit hub controlled by a program being processed in the system.

Normally, a carriage skip control relay point opens the pick to the auto start relay, R388 (Systems 3A). This stops the printing until the skip is completed. The R388 points open the circuits to the CF cam clutch magnet (Systems 3A), the type wheel contact and printing isolation control relays (Systems 5), and some special symbol exit hubs (Systems 13B).

The printer CR cams continue to turn to complete the skipping operation, but printing does not take place. The printer remains selected while the printing is being interlocked; therefore, no information is lost.

The printing resumes after the skip is completed, but at least one print cycle is lost for every skip taken unless interlocking is suppressed. The primary purpose of this interlocking is to prevent printing in flight for skips longer than two inches.

When the distance to be skipped is more than two inches, the printer must be interlocked at the start of the skip. The interlock may be released, however, by impulsing a short skip hub whenever the remaining distance to be skipped is two inches or less.

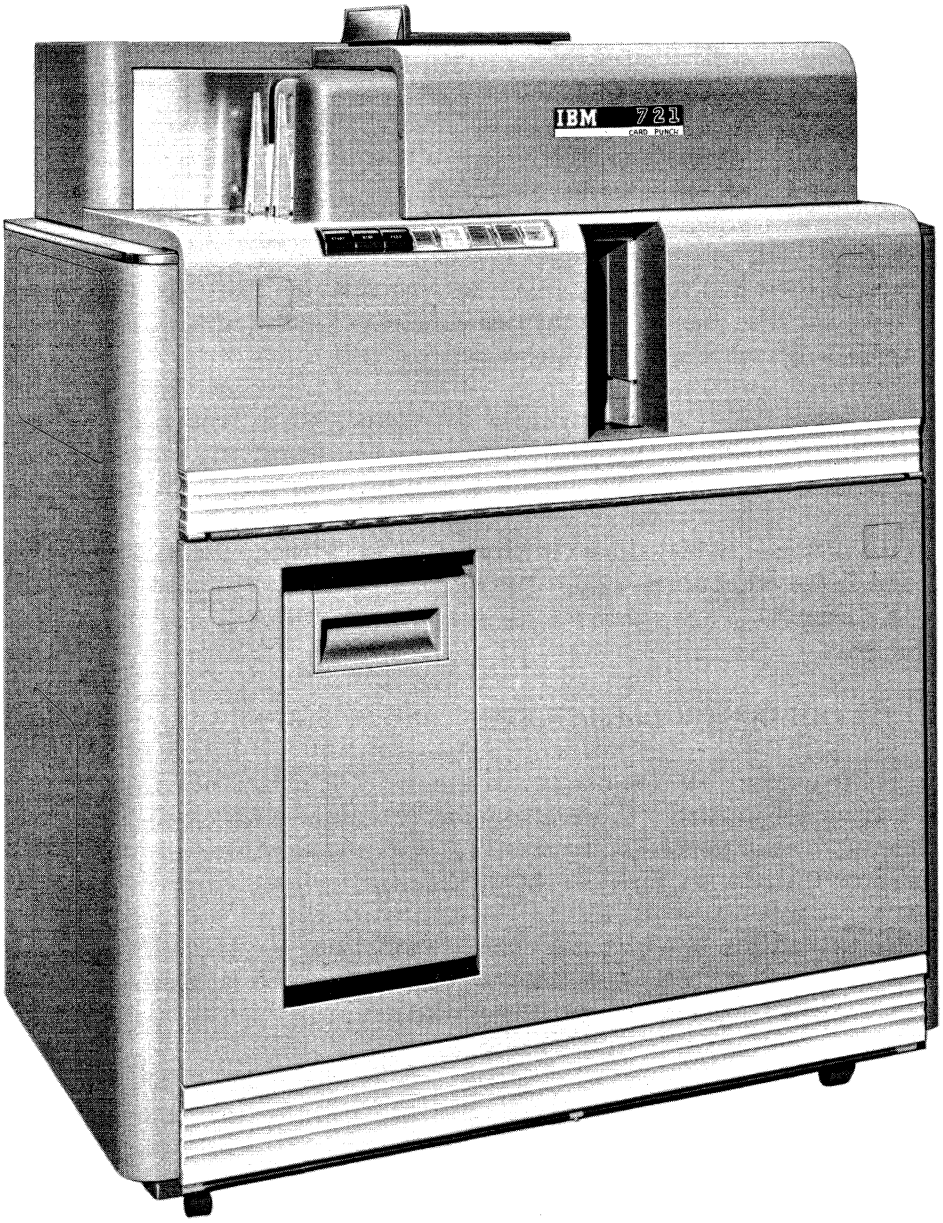
6.9.00 SYSTEM CONTROLLED SKIPPING AND SPACING

Impulses from the sense exit hubs are generally used to control skipping. These impulses are made available by programming within the external system. The programming is used to control suppressing or changing of line spacing, selecting the channel on the punched tape to control skipping, or sensing sheet overflow.

If the sense exit hub is wired to a carriage skip hub, the printer will start an after print skip operation at 338°. The line corresponding to the printer select instruction is printed after the skip operation is completed.

The R459 AU point (Systems 16A) is normally transferred. If the sense instruction is given when the CF cam clutch is latched up and CR42 is open, the sense relay circuit is completed through R459 AU. This point opens during a skip so the sense relay drops, even though the CF cam might stop closed. Had the sense instruction been programmed to control a selector relay, R459 would have been energized and the sense relay would have remained energized until 354° of the next print cycle.

The sense exit hubs are controlled in the same way (Systems 10A). Pulses are available at these hubs any time after 240° and before 350° of a print cycle if a skip operation is not to be performed. If the sense pulse starts a skip, the pulse can be made available between 245° and 340°, depending upon the pickup time of the sense relays.



IBM 721 CARD PUNCH

IBM 721 CARD PUNCH

1.0.00 INTRODUCTION

THE CARD PUNCH is used when it is desirable to store calculated information in punched form. The card provides space for storing 24 full binary words. Information is stored in the card in the same manner in which it is read, i.e., 9-row left and right, 8-row left and right---12-row left and right. The card punch operates at 100 cpm; therefore, it is capable of storing 2400 full words per minute.

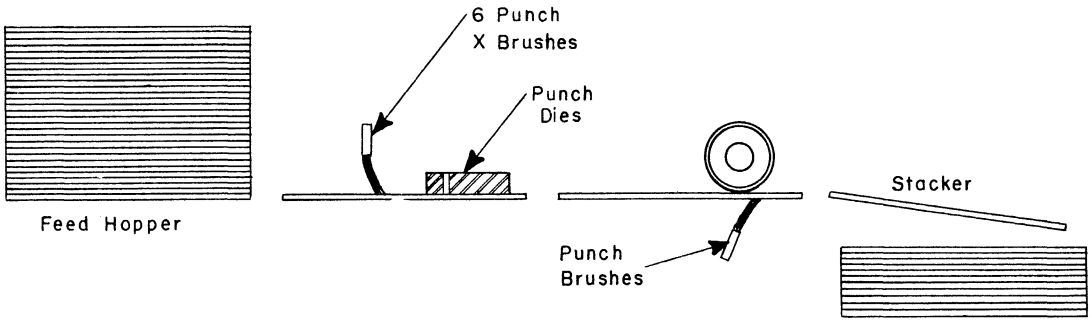
The card punch is not limited to punching data in binary form. The information may be punched in other notational forms according to the translation program operating in the system.

The card punch may also be used for gang punching. Gang punching can take place while the punch is operating independently of the calculator or while it is under calculator control.

Other features of the card punch are double punch and blank column detection and conditional transfer under relay control.

The schematic of feed and the punch control panel are shown in Figure 1.0–1.

The purposes of the control panel hubs are discussed in Section 3.4.00.



PUNCH UNIT - Schematic of Feed

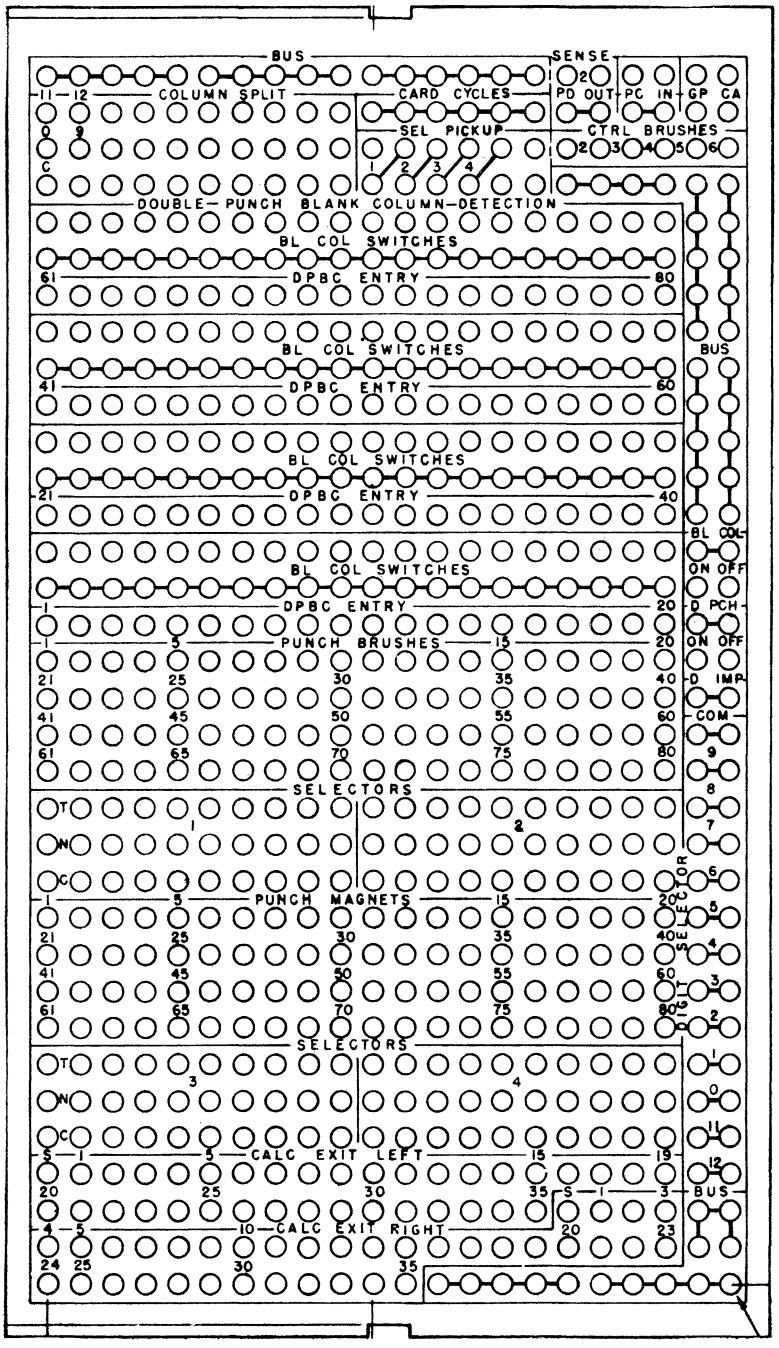


FIGURE 1.0-1. CONTROL PANEL

2.0.00 MECHANICAL PRINCIPLES

2.1.00 MACHINE UNITS

The card punch consists of a drive unit, punch feed, and punch magnet assembly. The drive unit consists of the motor drive, punch clutch, and the geneva mechanism. The feed consists of the hopper, feed knives, throat, feed rolls, gang punch brushes, and stacker. The punch magnet assembly consists of 80 magnets, 80 punch interposer assemblies, a punch bail, a die, and a stripper plate.

2.2.00 DRIVE UNIT

Power to drive the punch feed is furnished by the drive motor. The drive motor transmits power to a gear housing through a V-belt and pulley.

The feed unit is operated through the punch clutch. The clutch is a one-tooth ratchet driven by a train of gears from the drive housing. The drive housing and one-tooth ratchet operate continuously as long as the drive motor is running.

The sequence of power transmitted through the gear train in the drive housing is shown in Figure 2.2-1. The pulley turns the pulley shaft, to which are attached two gears. The gear toward the front of the machine drives the eccentric shaft. The gear toward the rear of the machine drives a large gear to the right of itself (facing rear of machine). This gear, the punch clutch idler gear, transmits motion to the oil pump rotor and the punch clutch one-tooth ratchet.

The index drive gear, the small spur gear outside the drive housing, is pinned to the same shaft as the punch clutch idler gear and, therefore, turns with the idler gear. The hub of the index gear serves as the one-tooth ratchet for the punch clutch. The clutch pawl arm, the P-cam drive gear, and the dynamic timer drive gears are pinned to the index gear shaft.

2.3.00 PRINCIPLES OF PUNCHING

The distance between any two of the twelve punching positions on the card is 1/4" and is called a cycle point. Therefore, for each cycle point, the card has moved 1/4" on its path through the machine. The card, being 3-1/4" wide, covers 13 cycle points, and in the feed there is 1/4" between cards. Therefore, the distance from the leading edge of the following card is 3-1/2". Since each 1/4" equals a cycle point, each cycle of the card punch is made up of fourteen cycle points. The machine index is divided into 14 divisions, and this machine is known as a fourteen-cycle-point machine.

If the machine is cranked over by hand, the operation of the twin eccentric shaft can be noted. Figure 2.3-1 shows the part the eccentric shaft plays in the punching operation. The circular motion of the gears and shaft is transformed into reciprocating (up and down) motion by the eccentric shaft. This up-and-down motion is imparted to the punch bail through the punch bail eccentric links. As shown in Figure 2.3-1, when the magnet is de-energized, the punch bail may move up and down without contacting the interposer; therefore, no punching takes place. When the punch magnet is energized, the armature is attracted, and through the magnet pull wire, pulls the punch

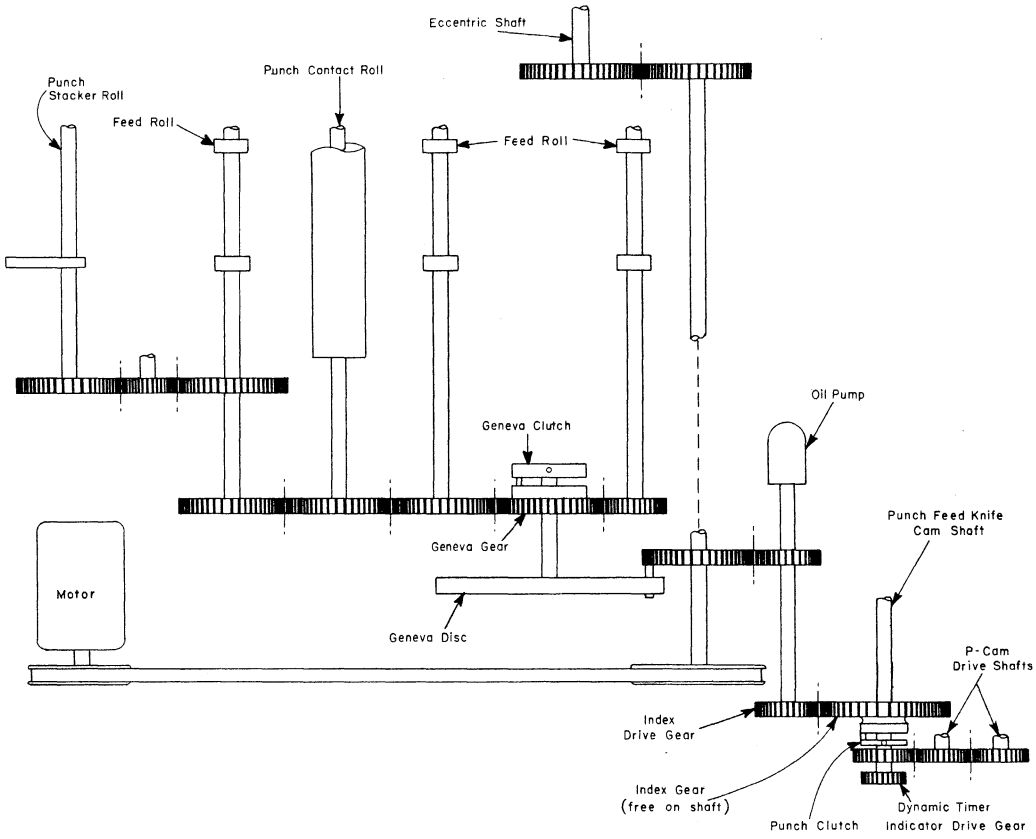


FIGURE 2.2-1. SCHEMATIC OF CLUTCH CONTROL

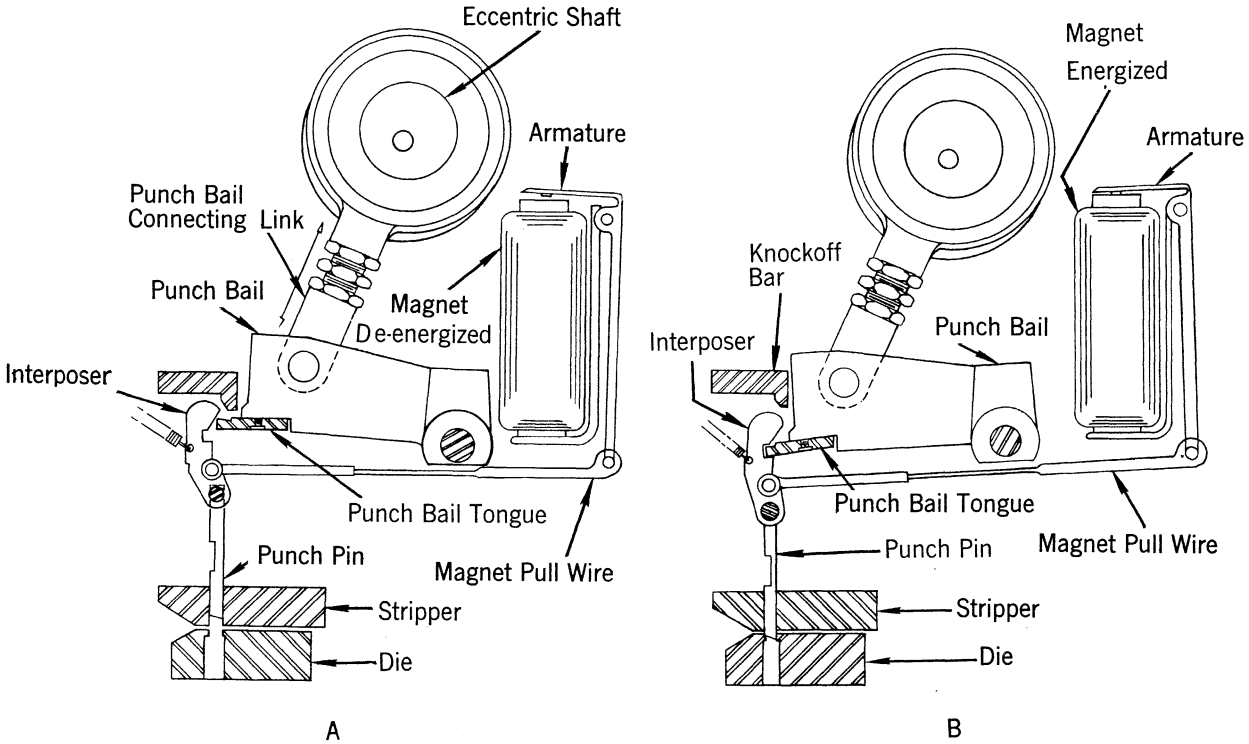


FIGURE 2.3-1. PRINCIPLE OF PUNCHING

interposer into engagement with the punch bail tongue. Since the bail tongue operates up and down, it forces the punch connected to the punch interposer down through the card. On the return stroke, the punch is positively withdrawn from the card by the upward motion of the punch bail. As the interposer approaches its upward limit of travel, it contacts the knockoff bar which cams it away from the punch bail tongue.

Eighty punches are arranged in a row, each with its individual interposer and magnet. There is but one punch bail which spans the eighty punches. The punch bail operates up and down once for every cycle point of a cycle. Any interposers which are pulled into engagement with the punch bail tongue cause their respective punches to be driven down through the card. Thus, if eighty magnets are impulsed, all eighty interposers are engaged with the punch bail and eighty holes are punched.

2.4.00 GENEVA MECHANISM

The punch bail moves up and down once for each cycle point to drive the punches through the card. While the punches are being driven through the card and withdrawn, the card must not be in motion. If the card were in motion, the holes would not be clean cut, but ragged and torn. Since the card must be stationary while it is being punched, and must then be moved to a new punching position fourteen times each cycle, the motion of the card must be intermittent. This intermittent motion is obtained by means of a geneva mechanism.

The geneva drive gear is located just inside the gear housing. It is pinned to the pulley shaft. It also drives the gear train which drives the punch clutch one-tooth ratchet . A stud and roller fastened to this gear operates in the slots of the driven member of the geneva gear (the geneva disk, Figure 2.4-1).

The hub of the geneva drive gear is a cam surface for approximately two-thirds of its periphery. This cam surface holds the feed rolls in a stationary position during punching time (Figure 2.4-1).

The geneva disk has seven deep slots and seven shallow cuts in it. The roller of the drive gear operates in the deep cuts in the geneva disk and the cam surface rides in the shallow cuts. As the drive roller leaves a deep cut of the geneva disk, the cam surface turns into a low cut, thus stopping the geneva disk from turning, and holding it still until the drive gear has rotated to a point where the drive roller enters the next deep slot of the geneva disk and starts driving. Then the cam surface has turned to a point where it releases the disk and allows it to turn freely. The geneva disk turns continuously as long as the drive motor runs, However, no motion is transmitted to the feed rolls until the geneva pawl is engaged with its one-tooth ratchet. The one-tooth ratchet gear is meshed with the feed roll drive gears. The geneva pawl and the geneva disk are pinned to the same shaft, which runs through the hub of the one-tooth ratchet. The one-tooth ratchet is free on the shaft and does not turn unless the geneva pawl is engaged (Figure 2.4-2).

When the punch clutch is not energized, the geneva pawl rides on the surface of the one-tooth ratchet during the greater part of the cycle. When the pawl reaches a point opposite the single tooth, the tail of the pawl strikes the pawl disengaging roller and is cammed away from the ratchet until it has moved past the point where it may engage in the single tooth of the ratchet. Figure 2.4-3 shows how the pawl disengaging roller prevents the geneva pawl from disengaging. From the above, it is evident that the operation of the geneva pawl is controlled by the pawl disengaging roller. The pawl dis-

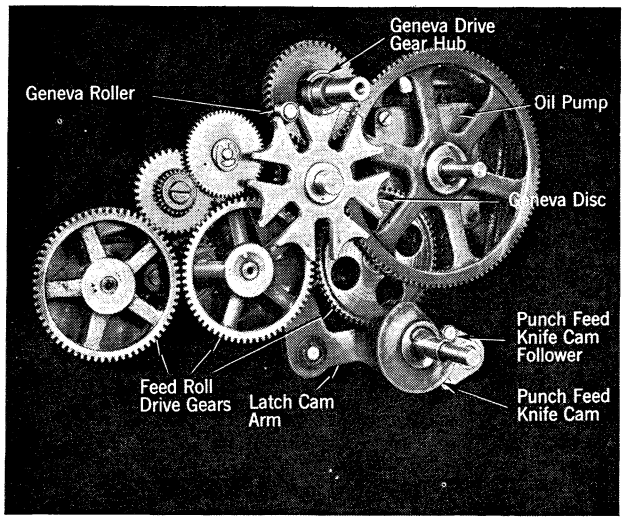


FIGURE 2.4-1. GENEVA MECHANISM

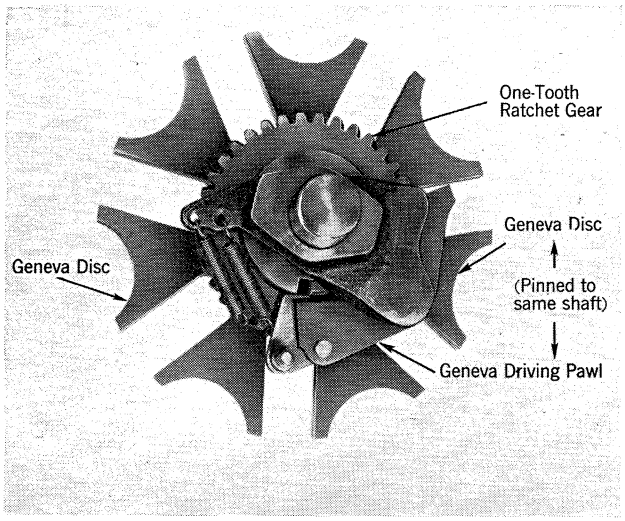


FIGURE 2.4-2. GENEVA PAWL AND RATCHET

engaging roller is mounted on a triangular plate which is free to pivot on the latch cam roller arm. The latch cam roller arm is operated by the feed knife and latch cam which turns only when the punch clutch is engaged. When the punch clutch is engaged, the latch cam turns, causing the latch cam arm to rotate in a counterclockwise direction. As the latch cam arm rotates, the upper end moves to the left and down, allowing the pawl disengaging roller to move past the single revolution timing cam, and thus allowing the geneva pawl to engage in the one-tooth ratchet. As the cycle is completed, the latch cam causes the latch cam arm to rotate in a clockwise direction, carrying the pawl disengaging roller to the right. The roller strikes the tail of the geneva pawl and disengages the pawl from the one-tooth ratchet when the roller is backed for the single-revolution timing cam.

2.5.00 SINGLE-REVOLUTION TIMING CAM

Since the geneva disk has seven cuts in it and moves the card one cycle point for each cut, and since the machine is a 14-point cycle machine, the geneva disk must make two revolutions per machine cycle. Therefore, the geneva pawl passes the pawl disengaging roller twice during each cycle. The purpose of the single revolution timing cam is precautionary. At the end of the first revolution of the geneva dog and intermittent disk, the flat side of the single revolution timing cam should be down (Figure 2.5-1). The pawl disengaging roller is free to swing away from the tail of the pawl. Therefore, if the geneva pawl should become disengaged from the one-tooth ratchet, possible because of a jam, it would be free to drop into the one-tooth ratchet on the next revolution. This assures that the pawl is not disengaged by the pawl disengaging roller until the punch unit mechanism reaches its proper latching position.

2.6.00 FEED KNIVES

The feed knives are designed to feed one card into the throat at a time. They are carried back and forth by a gear sector which meshes into the feed knife rack. The gear sector is pinned to a shaft which oscillates under the control of a cam and follower. Figure 2.6-1 shows the punch feed knife drive.

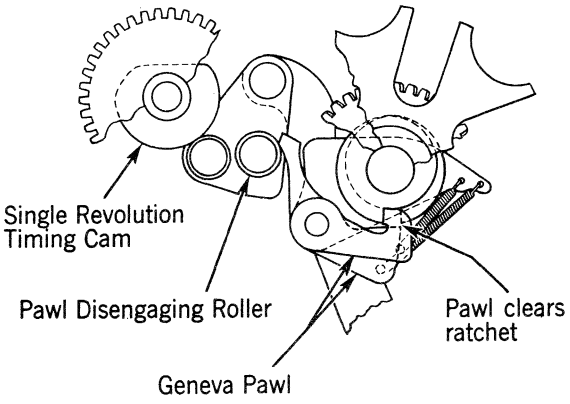


FIGURE 2.4-3. PAWL DISENGAGING ROLLER

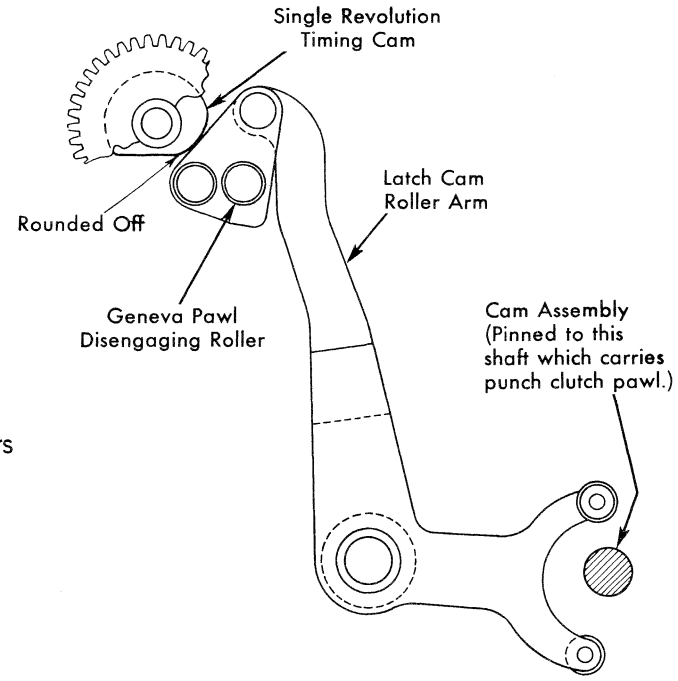


FIGURE 2.5-1. SINGLE REVOLUTION TIMING CAM

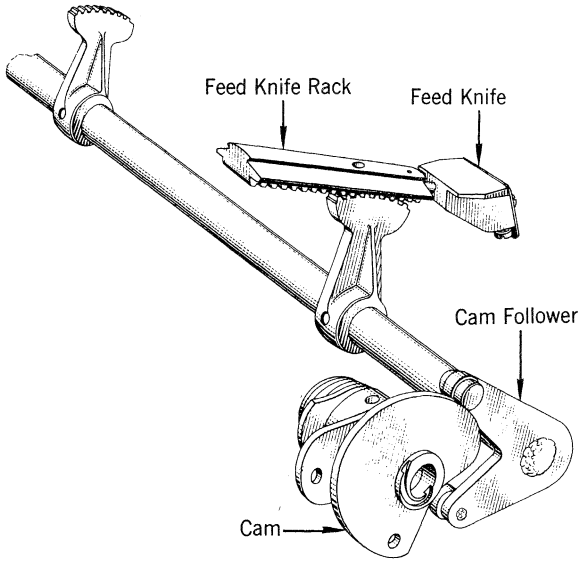


FIGURE 2.6-1. PUNCH FEED KNIFE DRIVE

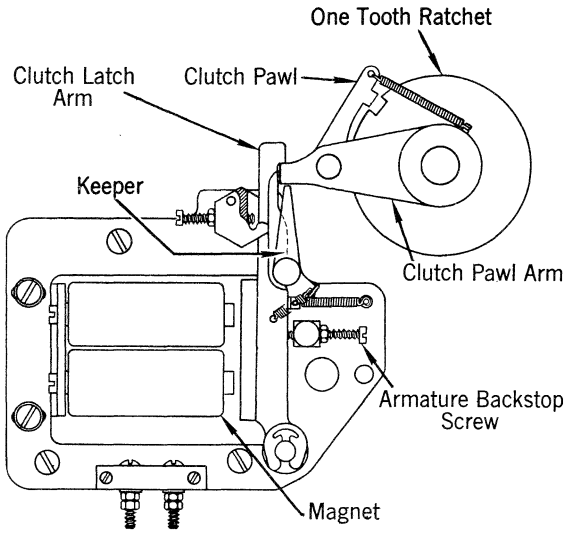


FIGURE 2.7-1. PUNCH CLUTCH

2.7.00 PUNCH CLUTCH

The punch clutch is of the one-tooth ratchet type (Figure 2.7-1). This is a common type on IBM equipment, and its operating principle should be firmly fixed in mind. The principle parts of the clutch are a continuously running one-tooth ratchet, a clutch pawl, a latching mechanism composed of a clutch latch arm and keeper, and a magnet. The magnet provides a means of electrically controlling the operation of the clutch. The clutch magnet armature serves as the latching mechanism. When the magnet is energized, the armature is attracted and allows the pawl to pivot in a clockwise direction by spring tension. The pawl drops into the continuously running one-tooth ratchet and turns with it. The pawl rotates about a stud on the clutch pawl arm, and the clutch pawl arm is pinned to a shaft; thus, when the pawl turns, the shaft to which the pawl arm is pinned must also turn. Since there is but one latching point, if the clutch latch is tripped, the pawl must make one complete revolution before it can be relatched. As the pawl reaches the end of the cycle, if the clutch magnet is de-energized, the armature is pawled by spring tension to a point where its latching surface engages the tail of the pawl and cams it out of the one-tooth ratchet. As the pawl is cammed out of the one-tooth ratchet, the keeper gets behind the clutch pawl arm. This prevents the shaft, to which the clutch pawl arm is attached, from turning backward.

2.8.00 OIL PUMP

The oil pump is a simple rotary-vane type pump. It is located inside the gear housing on the shaft of the small gear which drives the index (Figure 2.8-1). It pumps the oil from the bottom of the gear housing to the top, where it is free to run down over the geneva and gears.

The rotor is pivoted off-center in the housing, as shown in Figure 2.8-2. The expansion chamber at the inlet provides a vacuum and causes the oil to enter the pump from the well below. The compression chamber at the outlet causes oil to be forced out at the top.

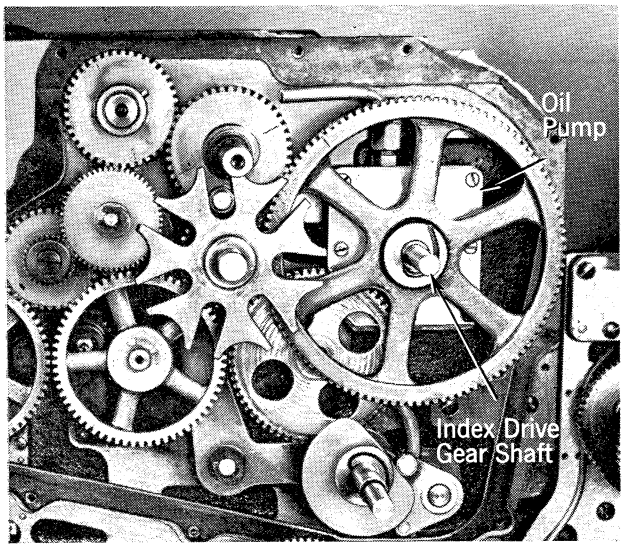
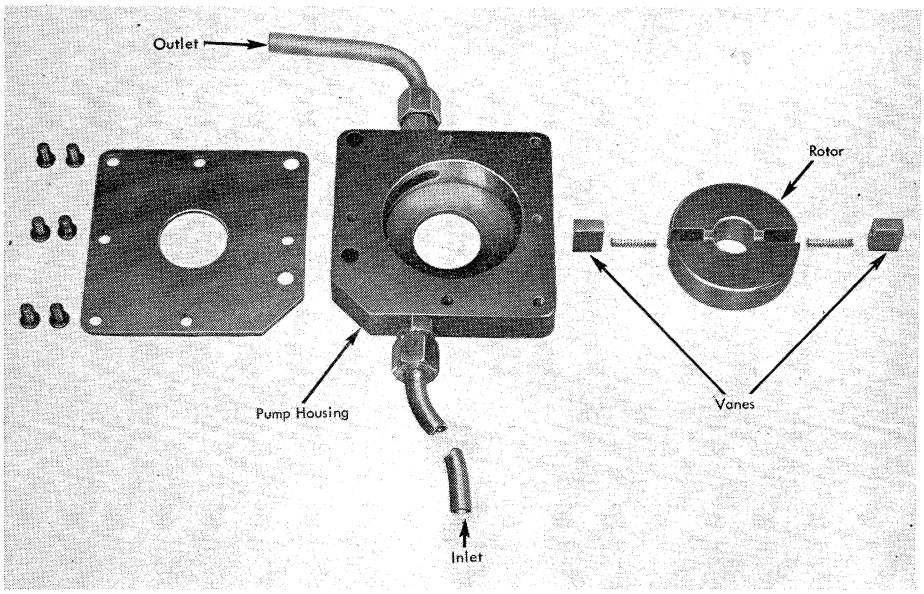


FIGURE 2.8-1. OIL PUMP MOUNTED



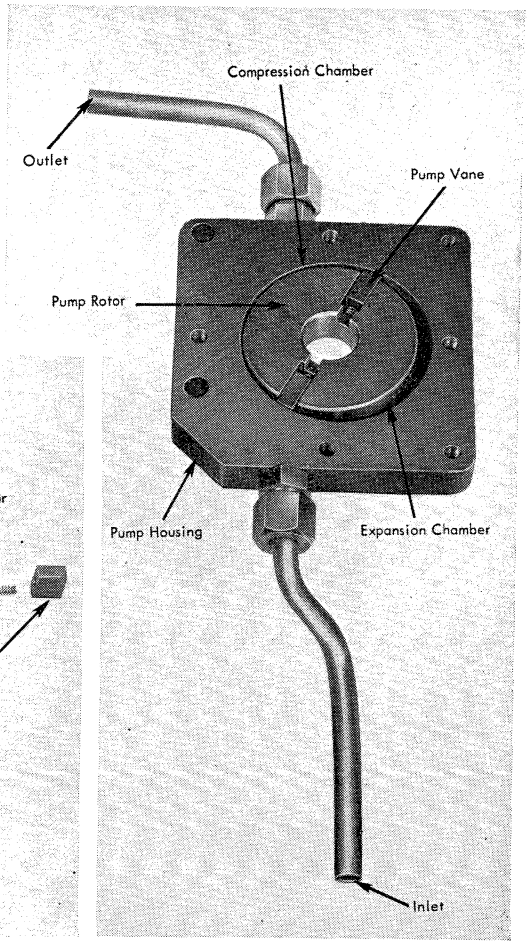


FIGURE 2.8-2. OIL PUMP

3.0.00 CIRCUIT DESCRIPTION

3.1.00 CARD PUNCH POWER SUPPLY

The card punch requires three voltage supplies, 115, 40, and 55. The 40 and 55 volt DC supplies are obtained from the printer generator and rectifier, respectively. The 40 volt supply is used to energize running circuit relays and selector relays. The 55 volt supply is used for the write thyratron, sense thyratron, selector thyratron, and disconnector thyratron plates. Also 55 volt pulses are used to turn on the CB signal triggers. The 115 volts AC supplies the drive motor.

The 40 and 55 volt buses are energized when the printer line switch is on. The 115 volt AC supply is available when the card punch line switch is on.

3.2.00 WIRING DIAGRAMS, RELAY CHARTS, CAM CHARTS, AND TIMING CHARTS (Systems Figures 36-42)

The wiring diagram for the card punch (Systems Figures 36-39) is drawn showing all contacts as they would be with the power turned off and the punch feed clutch in its latched position. In Systems Figure 40 the relay numbers and locations of the relay coils and points are listed. The size, type, and part number are also listed. Systems Figure 41 includes P-cam numbers, locations, make and break timings, descriptions and part numbers. Systems Figure 42 shows P-cam timing in relation to a machine cycle.

3.3.00 CONTROLS AND INDICATING LIGHTS

Start Key (Systems 3A)

The start key serves to run in cards initially and to turn over control of the card punch to the system. The key is operative only when the punch interposer knock-off bar is in place, the die is in place, the 40 and 55 volt supplies are available, no signal fuses are blown, the calculator or gang punch switch (Systems 1B) is on, the stacker is not full, the stop key is not depressed, the DP BC light is not on, and cards are in the punch hopper.

If there is no card waiting ahead of the punch station, pressing the start key causes the punch feed to operate for one cycle. When the first card reaches the punch station, the start key causes the punch clutch control to be turned over to the system and the ready light to turn on.

If there is a card ahead of the punch station, pressing the start key merely turns over control to the system and turns on the ready light.

Stop Key (Systems 2A)

The stop key causes the system to loose control over the card punch and turns off the ready light. If a card is being punched at the time the stop key is depressed, the action is delayed, and the card punch does not stop until the end of the current punch cycle.

Feed Key (Systems 3A)

The feed key permits cards to be run in and run out manually when the card punch is not under control of the system. If the knock-off and die contacts are closed, power is on, no signal fuses are blown, the control panel is in place, the stacker is not full, the stop button is not depressed, and the DP CB light is not on, pressing the feed key causes the punch feed to operate for one or more cycles until the button is released.

Ready Light (Systems 3B)

The ready light is on whenever the calculator interlock relay is energized. This light indicates that the card punch is under control of the calculator. While the ready light is on, no key can be used to feed cards.

Select Light (Systems 7B)

The select light goes on when the system gives a write instruction for the card punch. The light goes off as soon as the punch cycle called for by write instruction has begun.

Power-On Light (Systems 2B)

The power-on light indicates that the DC power is on the card punch.

DP BC Light (Systems 5B)

The DP BC light and interlock indicate that an error has been detected by the double-punch blank-column circuits. When the DP BC light and interlock go on, the calculator interlock relay is dropped out. The DP BC light and interlock are reset by means of the stop key, after which the start key must be depressed again to turn over control of the card punch to the system.

3.4.00 CARD PUNCH CONTROL PANEL

Column Split (Systems 3A-4A)

The 11-12 hubs are internally connected to the corresponding common hubs when the 11 and 12 punching positions of the card are being punched; the 0-9 hubs are connected to the common hubs when the 0-9 punching positions of the card are being punched.

Card Cycles (Systems 5A)

A pulse is available at these hubs during punching time of each punch feed cycle.

Selectors (Systems 4A)

The four 10-position selectors are controlled from sense exits, punch delay-out, or control brushes. When the selector relay is not energized, the C and N hubs are internally connected. When the selector relay is energized, the T and C hubs are connected.

Selector Pickup (Systems 4B)

The selector pickup hubs are receptive at all times. The selector relays are fully energized in less than one cycle point. They are held through punching time of the punch cycle during which they are energized.

Control Brushes (Systems 3A)

The control brushes read the X punching position of the card at 3/4 tooth before 13 time to 4-1/4 teeth after D time. Pulses are available at these hubs from 13.1 to 13.5. The control brushes are usually wired to selector pickup or PC-in hubs.

PC-In (Punch Control In) and PD-Out (Punch Delay Out)

When a delayed impulse is required to pick a selector, PC -in is wired from a punch control brush.

A pulse is available at PD-out hubs from 13.1 to 13.5 of the punch cycle following the punch cycle during which the X punch was sensed at the control brushes. The X punch was sensed by a control brush during the punch cycle before the card passed under the punches. At 13.1 to 13.5 of the following cycle, a pulse will be emitted from the PD-out hubs. The pulse will be used to control selectors while the X-punched card passes over the punch brushes.

D PCH (Double Punch) (Systems 6A)

To check card columns for double punches, wire the card columns to DP BC entry and jackplug the double-punch-on hubs.

B1 Col (Blank Column) (System 6B)

To check card columns for blank columns, wire the card columns to DP BC entry, wire the blank column switches, and jackplug the blank-column-on hubs.

D Imp (Digit Impulse) (Systems 5A)

These hubs are connected to P20, 21, 22, 23 which, in conjunction with P6, permit the hubs to emit an impulse for each digit on each punch cycle. When a digit impulse hub is wired to the common of the digit selector, the digit selector becomes a digit emitter.

Digit Selector (Systems 5A)

The digit selector serves as a digit selector or a digit emitter. When a card column is wired to a common hub, digit impulses are emitted at the selector hubs corresponding to the punched positions in the card. The digit selector may also be used to select impulses sent from the calculator.

Punch Brushes (Systems 5B)

These 80 hubs represent the 80 punch brushes. They are generally wired to the punch magnets for gang punching.

Punch Magnets (Systems 5B)

These 80 hubs are directly connected to the corresponding 80 punch magnets. They are wired from the calculator exit hubs (Systems 1A-2A) or from the punch brush hubs.

Calculator Exit Left and Calculator Exit Right (Systems 1A-2A)

The 72 calculator exit hubs are connected, through the calculator exit isolation relay points, to the corresponding distributor write thyratron cathodes.

Sense Exits 1 and 2 (Systems 8A)

A system-controlled impulse from the sense exit hubs can be used to control punching by energizing selector relays.

3.5.00 DYNAMIC TIMER

The dynamic timer is provided to facilitate checking of pulse timing and duration.

4.0.00 CIRCUITS

4.1.00 RUN-IN OF CARDS

The printer and card punch line switches are on, the calculator-on hubs are jack-plugged, the card punch control panel is in place, and there are cards in the card hopper (9 edge first, face down). Relays 4, 5, 12, and 3 (Systems 1B-2B) are energized. The P-cams are latched at 13.5 and the geneva mechanism is latched at 14.1. The relays and mechanical drive portion of the punch are shown in Figure 4.1-1.

The first momentary depression of the start key feeds the bottom card to a position just ahead of the punch station.

Before the first cycle can be started, the circuits to the drive motor and the punch clutch magnets must be completed. To complete these circuits, R10 (3B), R15, and the heavy duty relay (Systems 2B) must be energized.

The auto-start relay, R10, is energized from 40V-2 (Systems 2A), through the knock-off contact, die contact, R5-2n/o, R6-2n/c, R12-1n/o, stacker switch, stop key, R205-2, start key, R3-2n/o and R1-3n/c. Relay 10 is held through R10-1n/o (3B), P9, R6-2 n/c, R5-2n/o, die contact and knock-off contact to 40V-2. R10 holds until 9.2 of the first feed cycle.

The motor control relay, R15, and the heavy duty relay pick through R10-3n/o. These relays hold through R15-1n/o and CR9. The HDR-1n/o points complete the circuit to the drive motor. Thus the eccentric shaft, geneva disk, pump rotor, index gear (for which the punch clutch one-tooth ratchet is the hub), are set in motion.

The index was probably sitting between 6 and 9 before the motor started. The break time of CR9 determines this starting position. That is, the break time of CR9 (Systems 2A) determines the time at which the HDR-1 point opens. Thus, in order to save time on starting, CR9 should be timed so that the machine index coasts to some position as close to 9 as possible.

R10-4n/o and P1 complete the 40V circuit to the punch clutch magnet (Systems 3B).

The punch clutch pawl is unlatched from the punch clutch armature latch. At 13.5, or D time, the punch clutch pawl drops into the one-tooth ratchet. The punch clutch pawl arm is pinned to the index gear shaft. When this shaft starts turning, the feed knife cam and latch cam, the P cams, and the dynamic timer are set in motion.

The latch cam arm starts to rotate counterclockwise. The geneva pawl is going to drop into the geneva one-tooth ratchet at 14.1 time. Between 13.5 and 14.1, then, the latch cam arm must rotate counterclockwise far enough so that the tail of the geneva pawl does not strike the cam disengaging roller. When the geneva pawl drops into the one-tooth ratchet, the intermittent motion of the geneva disk is transmitted to the feed rolls, the contact roll, and the stacker roll.

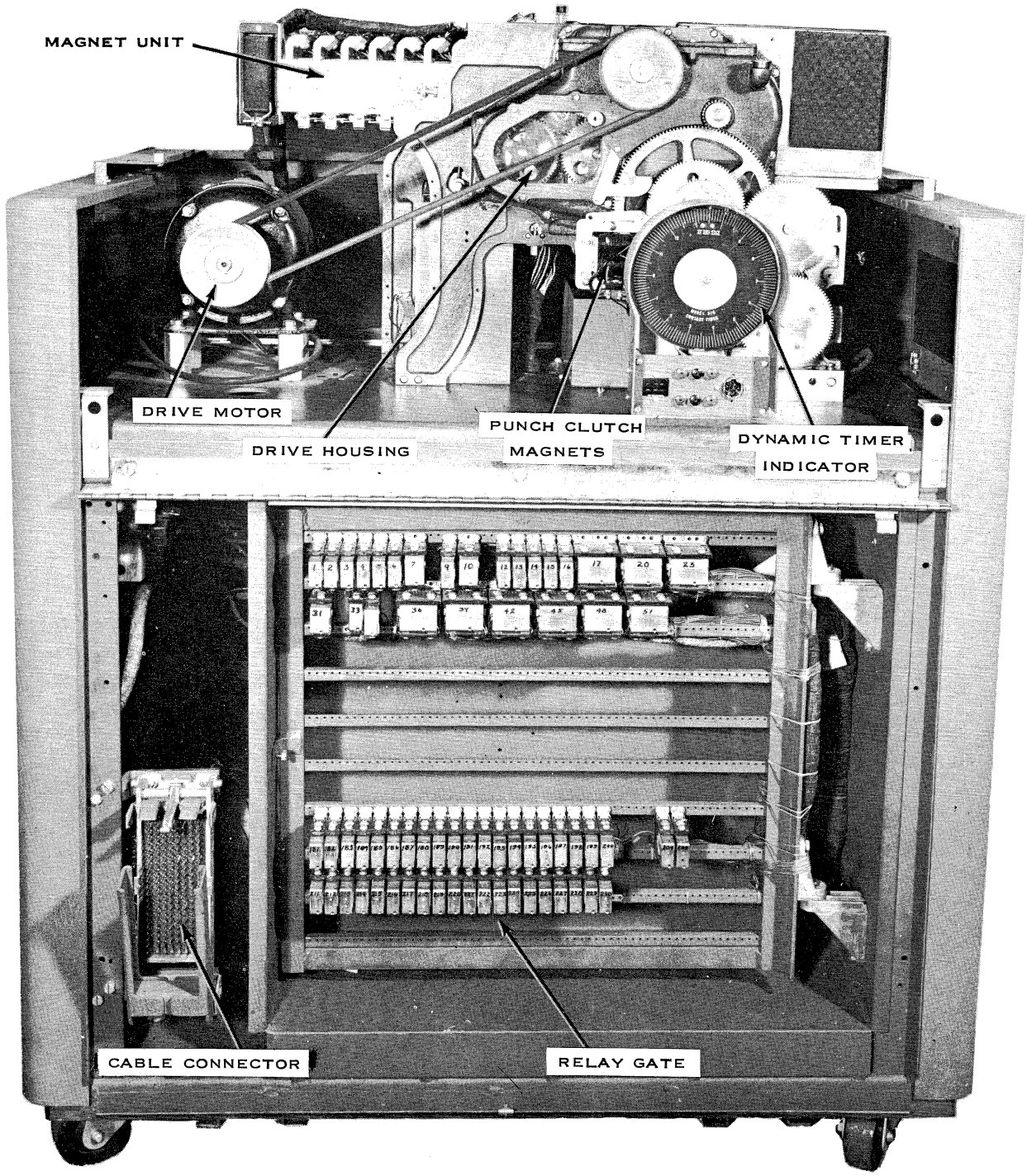


FIGURE 4.1-1. REAR VIEW

To summarize, energization of the punch clutch magnet causes two pawls to become engaged: the punch clutch pawl and the geneva pawl. The punch clutch pawl causes the feed knife cam and the latch cam, the P-cams, the dynamic timer to be set in motion. The movement of the latch cam arm permits the geneva clutch to engage the geneva one-tooth ratchet. This action causes the intermittent motion of the geneva disk to be transmitted to the feed rolls, the contact roll, and the stacker roll. As mentioned previously, the timing of this motion is such that the card is stopped while the punch is in the card.

The card is engaged by the feed knives at 2.5 time. It is pushed, 9 edge first, through the roller throat to the first set of feed rolls. The intermittent motion of the first set of feed rolls (that are stopped when the card strikes them) "buckles" the card slightly until motion is again transmitted to the feed rolls through the geneva mechanism.

The die card lever (Systems 2B) senses that a card is being fed. R1(Systems 2B) is picked through the die card lever contact. R1 picks at 7.0 time for a square-cut card and at 8.0 time for a corner-cut card. R1-3n/c opens the start key to pick to the auto-start relay. R2 is energized through R1-1n/o, R8-2n/o and R12-4n/o. R2 holds through R2-1n/o and P39 until 14.4 of the next cycle. The punch clutch magnets will become de-energized when P9 opens at 9.2 time.

At 13.5 time the tail of the punch clutch pawl latches on the punch clutch latch. This leaves the latch cam arm rotated to the left and upward. The tail of the geneva pawl strikes the pawl disengaging roller and, at 14.1, the geneva pawl becomes disengaged from the geneva one-tooth ratchet.

The punch feed is now latched with R3, 4, 5, 12, 2, and 1 energized. The second depression of the start key energizes R9, the calculator interlock relay (Systems 3B), and turns on the ready light. The R9-3n/o point must be closed or R274 (Systems 8B), the punch select control relay, cannot pick. R9 holds through R9-1n/o, R12-2n/o, and R2-2n/o.

The circuits are now conditioned for R33 (Systems 7B), the prepare-to-write relay, to be energized. When R33 is energized, the pick circuit to R10 is completed and a punch cycle is initiated.

4.2.00 INITIATING A MACHINE CYCLE

The card punch write select circuitry is shown in Systems 8A. The circuit is from the 55 volt bus, through P33, to the system for gating. The select return from the system is to the pick of R33 (Systems 7B). With R33 and R9 up, the auto-start relay, R10, picks and the card punch feeds another card. Under control of P33, the select circuit may be activated at any time between 14.9 and 14.2 of the punch cycle.

Relays 2, 8, and 35 (Systems 5B) are brush card lever interlock relays. During this cycle R2 drops and R8 and R35 pick. The interlock circuitry is explained in Section 4.4.00.

The card punch might be selected before the cards are run into the punch station. In this case, R33 is held energized through R9-4n/c (Systems 8A) until a card is fed into the punching station. P33 opens at 14.2 to drop R33.

Select gating is again available to the system at 14.9. This permits a second CP write select instruction to be executed if disconnect should occur at "12" time of the card punch cycle (9 row writing time). R274 (Systems 8B) is energized through R33-3n/o, R9-3n/o, and P16 at 13.6 time. R274 holds and R275 (Systems 8B) picks through the R274AU point, R273AL, and P17 until the card punch is disconnected. The R274AL and BL points close the write thyratron plate circuits (Systems 7A) and calculator exit isolation relays (R26-51) circuit (Systems 8B). The CB signal trigger reset control relay, R34 (Systems 8B), is energized through R275A and P17. R34 holds until R31 picks after a disconnect. R275B (Systems 8B) closes the CB signal trigger set circuit until a disconnect occurs.

A card is in motion and the card punch circuits are now ready for the information to be sent from the system.

4.3.00 TRANSFER OF INFORMATION AND DISCONNECT

Two major controls are employed in the card punch to provide synchronization for data transfer to the punch magnets. The "CB signal trigger set" control, generated through P27 and P28 (Systems 7B), signals the system that setup time for a row of punching is at hand. The system must then take action to ready data for transmission.

The second control to gate the data to the punch is in the form of "CP thyratron plate" lines. These lines are available to the system at setup time through P-cams 10, 11, 13 and 14 (Systems 8A). Data to be punched are routed through the isolation relay points to the calculator exit hubs (Systems 1-2A). The pulses received are then generally conducted to the punch magnets (Systems 5B) through control panel wiring. Because of the nature of the external system a fractional second of delay occurs between impulsing of calculator exit-left and calculator exit-right hubs. This delay is too minute to have any effect on the impulsing of the punch magnets.

The P cam and card control circuitry timings are such that the above operation occurs when the punch bail has just started to descend. The selected interposers are pulled into the line of travel of the punch bail tongue. When the bail descends, the corresponding punches are driven into the card. The punches are positively withdrawn when the punch bail rises, and the magnet armatures are restored when the interposer strikes the knock-off bar. These operations continue through the 12 punching positions of the card.

A "CB signal trigger reset" control (Systems 7B) is generated before transmission time for the 9-row and after transmission time for all rows. This control serves to reset the cord control circuitry within the external system.

At the end of data transmission a disconnect control is sent from the system to pick R276 (Systems 8B). R276B opens the pick to R275, the punch select relay. The R275B point opens to stop the CB signal trigger set pulses.

R276A closes the pick circuit to R273, the disconnect control relay. When P36 makes at four teeth after the line of index, R273 picks. R273 holds through R273AU and P17 until 13.4.

R273AL opens the R274 hold circuit. R274AL and R274BL opening stops the write thyratron gating pulses. R274BU opens the pick to the calculator exit isolation relays.

R273BL closes the pick circuit to R31, the delayed disconnect relay. This drops R34, the CB signal trigger reset control relay.

R34 does not drop until the CB time following the disconnect. This assures that the CB signal trigger reset pulse gets through after the disconnect CB time.

4.4.00 FEED INTERLOCKS

Last Card Feeds from Hopper

The magazine card lever opens at 8.9 of the cycle during which the last card feeds from the hopper. This drops R3 (Systems 2B). R3-1 opens the hold to the calculator interlock relay, R9 (Systems 3B). The ready light goes out at the same time that R9 is dropped. R9-2 opens the circuit to the pick coil of the auto-start relay, R10 (Systems 3B). R10H drops at 9.2 and the punch feed latches up at 14.1; the P-cams are latched at 13.5.

The feed key can now be depressed to run out the remaining cards, if this is desired.

If more cards are placed in the magazine and the start key is depressed until the ready light comes on, punching can continue under system control.

Had the punch been selected after the last card was fed, and had the remaining cards been removed from the feed by using the feed key, the punch prepare-to-write relay, R33, would have been held energized through R9-4. The punch remains selected until a card is again introduced into the feed and the ready light is turned on.

Failure to Feed a Card from the Hopper

When a card fails to feed from the hopper, the die card lever breaks at 7.9 or 9.0 (of the cycle during which the misfeed occurs) depending upon the corner cut of the card being fed. This causes R1 to drop (Systems 2B). R1-1 (3A) opens to drop R9H and turn off the ready light. The machine stops with the P-cams latched at 13.5 and the punch feed latched at 14.1.

The card that failed to feed is replaced, and the start key is depressed until the ready light comes on.

Had the punch been selected after the misfeed occurred, it would have remained selected through R9-4, as described above.

Card Fails to Close Punch Brush Card Lever Contact

A third interlock is provided to prevent destroying more than two cards when a jam occurs after the die station. When a card fails to close the punch brush card lever, R7 drops (Systems 2B). This happens at 13.0 or 14.0, depending upon the type of card that just fed past the punch brushes (square-cut or corner-cut card).

The machine stops after R7-2 opens the R9 hold (Systems 3B). When R7 drops, R35 is picked through R7-3n/c, R2-3n/c, and R8-3n/o (Systems 5B). R8 holds until the feed is cleared.

R35 remains energized until the feed is cleared. R35-3n/c prevents the pick of R9 by the start key; therefore, the feed key must be used to clear the feed.

This circuit is not operative when the punch is not under system control.

4.5.00 DOUBLE PUNCH AND BLANK COLUMN DETECTION

To check card columns for double punches, wire the card columns to DP BC entry and jackplug the double-punch on hubs.

To check card columns for blank columns, wire the card columns to DP BC entry, wire the blank-column switches, and jackplug the blank-column-on hubs. This device has limited advantage when punching binary cards.

The double punch and blank column detection unit is a device that detects the lack of a hole or the presence of more than one hole in any column or columns of a card.

The cards may be checked for double punches or blank columns during a regular run through the machine. The detection of an error stops the card punch and turns on the double punch and blank column detection light.

Double Punch Detection Circuit

Assume that the column being sensed is wired to DP BC entry 1 (Systems 6A).

When a punch is sensed in some column, R182 picks (6B). The circuit is from 40V-2, through P6 (Systems 5A), 20, 21, 22, and 23, R7 points, the hole in the card, control panel wire from punch brush hub to DP BC entry 1, and R181-2 to R182P. R182 holds through R182-1 and P19 for the remainder of card reading time.

R182 picked on the line of index. At four teeth past the line of index, P36 makes. At this time R181 picked through R182-2 and P36. R181 holds through R181-1 and P19.

When the second punch in the same column is sensed, R204 picks through R181-2n/o and the double punch switch. R204 holds through R204-1 and P19.

When P7 (Systems 5A) makes at 9.4, R205 picks. R205 holds through the stop key contacts, and so on, to the line.

When R205-2n/c (Systems 2A) opens at 9.4, the calculator interlock relay (R9), hold circuit and the auto-start relay (R10), pick circuit are opened. Thus, the card punch stops when the current punch cycle is completed.

The stop interlock may be released by depressing the stop key to drop R205, then depressing the start key to again energize R9, the calculator interlock relay, and turn on the ready light.

Blank Column Detection Circuit

When a card column having no punches is wired to a DP BC entry hub and the blank column switches are wired, control relays are picked to stop the machine.

As seen in Systems Section 6, there are twenty parallel paths from P19, through relay points and blank column switches, to the R204 pick.

If some column wired to DP BC entry does not contain a punch, then one of the relays, R182 through R230, is not picked. This provides a path to R204 through R19, the n/c points of the relay corresponding to the column not containing a punch, a blank column switch, P8, and the blank-column-on switch.

R205 picks and holds as described above and the machine stops. The stop interlock is released by depressing the stop key.

IBM®

International Business Machines Corporation
Data Processing Division, 112 East Post Road, White Plains, N.Y.

Form 223-6861
Printed in U.S.A. (10/59:500-EP-394)